STABLE SANITATION AND CONSTRUCTION

T. E. COLEMAN

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STABLE

SANITATION AND CONSTRUCTION.

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PREFACE.

The chief object of this book is to bring together in a compact form the numerous important facts and principles which refer to the sanitary construction of stables; and to indicate, as far as possible, the simplest and best means which may be adopted so as to obtain the most satisfactory results.

For the convenience of Architects, Estate Agents, and others who are professionally engaged in stable design and construction, and also for those who are horse and stock owners, it is oftentimes advantageous to have at hand some concise manual treating of the different details relating to such buildings. In this connection I trust the present volume will be found helpful as a book of reference.

The subject-matter in the following pages recently appeared in a series of articles contributed to the *Building News*, and is now issued in a collected form with such slight alterations as were considered necessary to adapt it for everyday use.

Throughout the entire work the greatest care has been taken to discuss the subject more particularly from the standpoint of thorough sanitary efficiency, but at the same time the practical side of the question has been kept constantly in view. I have accordingly described and illustrated various arrangements of stabling, together with many of the most modern and approved types of stable fittings which have been introduced for the purpose of securing a convenient and healthy building.

T. E. COLEMAN.

LINDEN GROVE, GOSPORT.
October 1897.

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STABLE
SANITATION AND CONSTRUCTION.

CHAPTER I.

INTRODUCTION.

INTRODUCTION:—Importance of properly constructed buildings—Insanitary stables and cow-houses the cause of much disease—Epidemics of typhoid fever traceable to infected milk—Legislative measures—Powers of local authorities for enforcing adequate sanitary arrangements in cow-houses and dairies—Frequent and thorough cleansing of stables a necessity—Definition of "stable"—Classification—Chief objects to be attained in their construction—Healthy stables commercially advantageous.

DOMESTICATED animals, such as horses, cattle, &c., cannot be maintained in a thoroughly robust state of health unless the buildings in which they are housed are designed and constructed with a due regard to sanitary efficiency. Of late years great improvements have been made respecting the various details of construction, with the result that for stables, cow-houses, and piggeries of the best class, the general arrangements are now practically all that can be desired.

At one time—to judge from the stable buildings that were commonly met with in all parts of the country—it was apparently assumed that any sort of insanitary and dilapidated shed might be permanently utilised for this purpose. No consideration appeared to be given to the healthy and comfortable housing of the animals themselves, the chief

object frequently being to crowd the maximum number of living creatures into the minimum cubic space that might be found practicable, and at the smallest cost that could be incurred. Such erections were frequently damp and dark, having also a close, evil-smelling atmosphere, so that the conditions of animal life amidst such unwholesome surroundings were the most unfavourable that could well be conceived. It is, therefore, scarcely to be wondered at that places of this description in time became breeding grounds for various diseases, which, in many instances, were capable of being communicated to man, either directly or indirectly.

The sanitary condition of cow-houses espcciaIly exerts a most important and direct influence upon the health of the community at large, for certain diseases which are liablc to be contracted by cows as a consequence of their confinement within dirty, badly drained, and ill-ventilated buildings may be directly transmitted, through the medium of their milk, to persons using the same as an article of diet. As an instance of the serious attention which should be given to this view of the matter, it may be mentioned that somc of the most virulent epidemics of typhoid or enteric fever which have occurred in this country within recent years are directly traceable to the use of milk which has previously become infected. This has been demonstrated by the fact that the disease has in many instances been confined within the limits of certain families receiving their milk supplies from thc same source.

From time to time much has been done towards the compulsory improvemcnt of the hygienic condition of this class of building by means of judicious legislation, so that the local and other authorities are now in a position to enforce some degree of sanitation—at least as regards the lighting, ventilation, cleansing, drainage, and water supply of cow-houscs in the occupation of all following the calling of a cow-keeper or dairyman. Under the Dairies, Cowsheds,

and Milkshops Order of 1885, and the Contagious Diseases (Animals) Act of 1886, the local authorities may insist on the provision of adequate sanitary arrangements in cow-houses for the prevention of disease amongst animals, and for properly safeguarding the public health.

In addition to the provision of stables which are properly drained, ventilated, and lighted, it is necessary that they should be frequently and systematically cleansed, or the advantages to be gained from well designed and constructed buildings may be rendered in a great degree inoperative. Considering that a large amount of solid excrement is deposited within the building where the animals are sheltered—the emanations from which are delcterious to health—it is important that such effete organic matters should be removed as soon as possible.

The word "stable," when used in its broadest and most extended significance, includes every description of building designed for the lodgment of animals in a state of domesticity; but as generally understood, the term more particularly refers to those buildings which are used for the accommodation of horses only. Whilst, therefore, using the word stable in its restricted and commonly accepted sense of referring to any erection exclusively intended for the reception of horses, yet at the same time it is proposed to consider in the following pages any special requirements which are necessary to the proper construction of buildings for effectively housing various other domesticated animals. When buildings of this description are under consideration they will be specifically referred to as cow-houses, piggeries, or kennels, as the case may be.

Stables vary considerably in details of construction and arrangement, according to the class of horses they are designed to accommodate; but whatever the differences which are thus necessitated, it is essential that they should one and all comply with certain sanitary requirements if they are intended to exercise no injurious effects upon the

health of the animals confined therein. For general purposes stables may be divided into five classes, viz.:—

1. Stables for racing and hunting establishments; also those intended for housing the carriage and saddle horses of the wealthy, such as are attached to country and town mansions. These buildings are frequently designed and fitted up regardless of expense, providing at once the most convenient and luxurious description of stables that can be erected; but they cannot in all cases be considered the most healthy, as they are sometimes deficient in adequate means of ventilation.

2. Stables attached to the town and country residences of gentlemen of moderate fortune. Whilst every attention is usually given so as to secure the health and comfort of the horses, they differ from the previous class, insomuch that the fittings and furnishings generally are of a simpler and less expensive character, but at the same time thoroughly good and serviceable.

3. Stables for the accommodation of large numbers of horses, as required for army purposes, omnibus and tramway companies, and for large business firms and general carriers. In stables of this type, the question of first cost of construction and the amount of annual maintenance involved becomes an important matter, so that it is necessary that everything connected therewith shall be of the utmost simplicity of construction consistent with the health and comfort of the horses. The horses themselves are generally of a hardier and more robust nature than those for which the preceding descriptions of stabling are intended, so that the ventilating and other arrangements may be greatly simplified. As horses of this class do not usually pass so much time within the stable as those previously mentioned, the amount of space provided per head is frequently reduced on economic grounds, so far as this is compatible with sanitary efficiency.

4. Livery and Hackney Stables. Cheapness of construc-

tion is usually the first consideration in stables of this class, the provision of accommodation suitable for thoroughly maintaining the health of the horse being frequently a minor matter. The fittings are of a simple and inexpensive description.

5. Farm Stables. As a rule, these are the cheapest class of stable buildings erected. The fittings are generally of a primitive character, being largely constructed of wood. Such fittings, although they cannot be considered as complying with modern sanitary requirements, have the advantage that they can be easily repaired by any handy man, which is a great consideration and convenience in country districts. The drainage arrangements are frequently inadequate; whilst the ventilation consists in most cases of a few hit-and-miss ventilating windows arranged in a haphazard fashion.

Cow-houses, as a whole, are more uniform in general design, the chief differences being in the character of the fittings and ventilating appliances. In cow-houses of the best and most modern construction the fittings are of iron, whilst an ample supply of light and air is provided; but for ordinary dairies and farm buildings the fittings are still in a great measure made of wood, the drainage and ventilation of the building being effected in the simplest and cheapest manner.

To secure the highest degree of sanitary efficiency in the construction of stables and cow-byres, the chief objects to be attained may be summarised as follows, viz.:—

1. A well-drained site, sheltered from cold winds, together with abundance of light and pure air.
2. The buildings to be quite dry, and free from damp.
3. Thorough ventilation.
4. Adequate drainage arrangements.

The importance of supplying an abundance of fresh air for breathing purposes cannot be over-estimated, for it is found that consumption and other lung diseases are directly

attributable to defective and insufficient ventilation, whilst a general loss of vitality and power of resisting the various diseases common to horses and cattle are traceable to the same cause.

Even from a business point of view, it is desirable that the stables, cow-houses, &c., shall be so designed as to be perfectly healthy and comfortable. Where horses and cattle are confined for any length of time in a badly-lighted, ill-ventilated, and defectively-drained building, their general health must of necessity suffer and their market value be proportionately reduced. Indirectly, another pecuniary advantage is obtained, insomuch that the animals derive more benefit from their food when confined and fed in a warm, dry, and well-ventilated building. Accordingly, the provision of thoroughly sanitary buildings becomes a matter of the utmost consequence, and it is therefore proposed to consider in detail the best practical means of effecting this desideratum.

CHAPTER II.

THE SITE. GENERAL ARRANGEMENT AND CONSTRUCTION.

THE SITE :—High, dry land desirable—Marshy ground to be avoided—Comparative values of different soils or formations for building purposes—Sub-soil drainage—Stables to be protected from cold winds—Aspect.

GENERAL ARRANGEMENT AND CONSTRUCTION :—Example of stable buildings suitable for a country residence—Buildings to be free from damp—Construction of stable floor—Stone walls—Solid brick walls—Hollow or cavity walls—Iron wall ties—Stoneware bonding bricks—Details relating to hollow walls—Damp proof course—Rounded angles to be provided to all openings.

THE SITE.

THE choice of a site for stables is usually limited by the local circumstances governing each specific case, so that it may be necessary to erect the buildings on a particular plot of land irrespective of its suitability for the purpose. In places where the free selection of a suitable site can be made, it is important to consider the situation and nature of the ground, and the position of the buildings in relation to aspect, wind, air, and light.

The best situation for stables is on high, dry land, having such a physical conformation that the whole of the surrounding area is naturally drained so far as the surface-water is concerned. Marshy, low-lying ground should be avoided where possible.

With regard to the nature of the ground itself on which to erect buildings of this description, nothing can be better than a thick bed of gravel or sand, so that any surface water

is quickly carried away, leaving the upper part of the ground dry. Next to porous self-draining soils of this class may be placed a rocky formation, such as limestone, sandstone, chalk, or granite. Land of a stiff, impervious nature —such as heavy clays, &c.—is objectionable, whilst alluvial soils and made ground should, as a general rule, be regarded with suspicion, and, in any case, carefully examined before building thereon.

The site having been duly selected, it becomes necessary to ascertain what is required in the way of subsoil drainage. It is desirable that provision should be made for the whole of the surrounding area being thoroughly drained to a depth of about 5 feet from the surface, in order that the normal level of the ground water or land soakage may be kept well below the surface of the ground.

If practicable, the stables should be so arranged that they are protected in some measure from excessive and cold winds; but the air should be free to circulate on all sides of the building. Provided they are sheltered in this manner, the actual aspect obtainable does not become a matter of very great moment; but in places where a choice is given, a south or west aspect is to be preferred where possible. Similar considerations to those mentioned for stables should also govern the selection of a site for cow-houses and other buildings of a similar character.

General Arrangement and Construction.

The disposition of the various buildings required for stable purposes will differ in almost every instance, according to the site available and the amount of accommodation desired. Fig. 1 is a typical arrangement of the principal stable buildings and accessories required in connection with a gentleman's country residence. Accommodation is provided for nine horses, together with a sick-box, coach-house, harness-room, cleaning-room, hay and straw store, manure

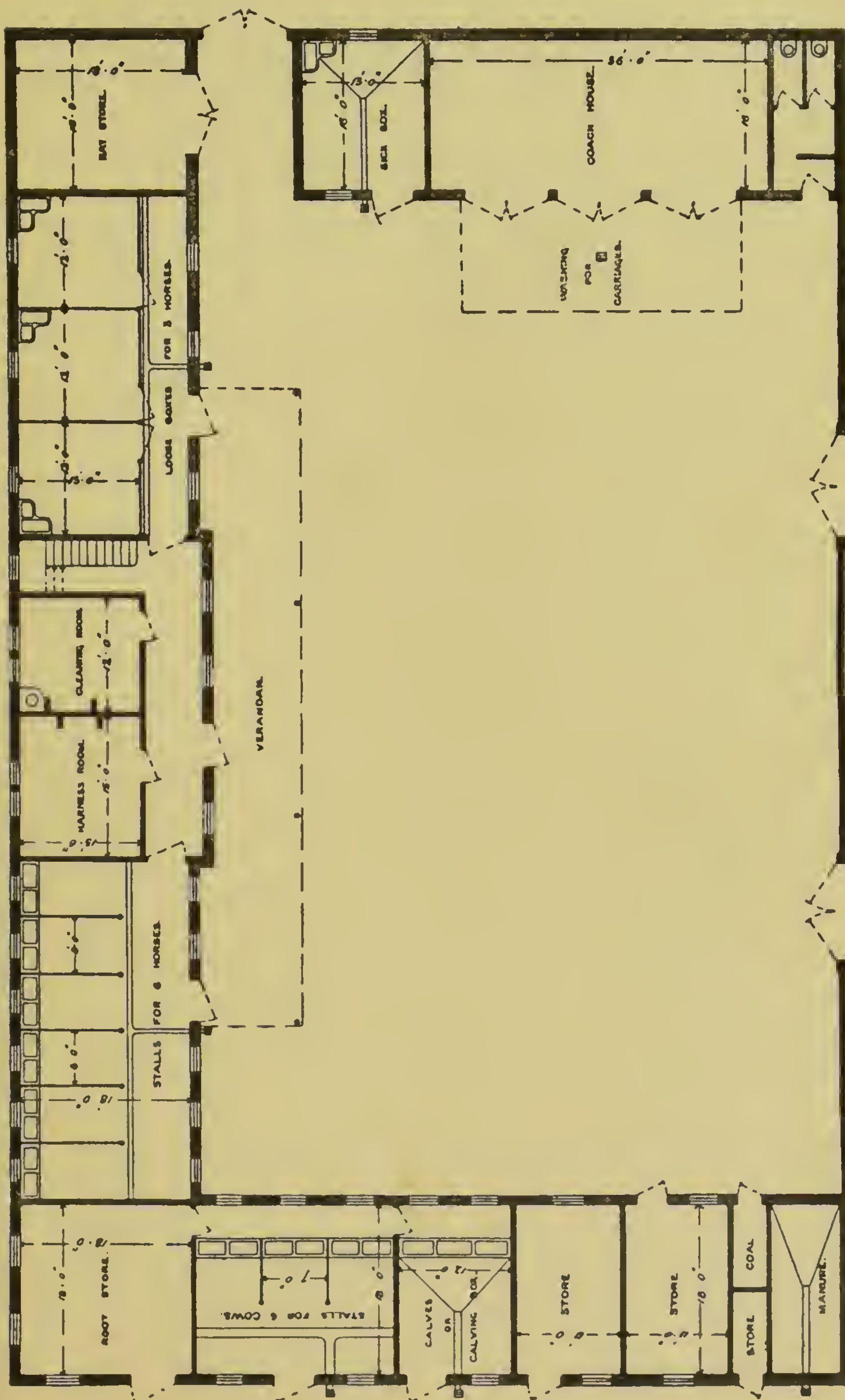

HAY STORE
SICK BOX
COACH HOUSE
36' 0"
WASHING FOR CARRIAGES
LOOSE BOXES FOR 3 HORSES
CLEANING ROOM
HARNESS ROOM
VERANDAH
STALLS FOR 6 HORSES
ROOT STORE
STALLS FOR 6 COWS
CALVES OR CALVING BOX
STORE
STORE
COAL
STORE
MANURE

FIG. 1.

pit, &c. Stalls for six cows, a loose-box for calves, root and other stores are also provided. The entrances to the latter group of buildings are quite distinct from the stable yard proper, so as to avoid any subsequent confusion in the management of the horses and cattle.

Additional stores, or sleeping and living rooms for the stablemen, are arranged over the harness and cleaning-rooms to suit the requirements of the case.

In the construction of stables, cow-houses, &c., care should be taken that the interiors of the buildings are rendered permanently weatherproof and free from damp. To effect this object it is necessary to prevent any ground moisture or vapour rising through the floor and foundations of the walls, nor should any moisture be capable of being driven from the outside through the walls themselves in wet and stormy weather. The floor-level of the stable must be higher than the ground outside. The whole area enclosed by the stable walls should be excavated to the requisite depth, and a layer of hard, dry, broken brick rubbish, about 6 inches thick, spread over the entire surface and well rammed. A bed of Portland cement concrete from 4 to 6 inches thick should then be laid upon the brick rubbish, the surface of the concrete being floated to proper falls ready to receive the stable paving. The finished surface may be of brick, concrete, or other material; but the selection of a suitable stable paving will be further considered. Where this method of forming the stable floor is properly carried out, there will be no danger of ground-moisture or noxious vapours arising through the floor itself.

The walls of stables, whether of brick or stone, are usually built solid. Where stone is plentiful, the external walls may be built of coursed rubble hammer-dressed stone, with an internal brick lining 4½ inches thick, the whole being securely bonded together. Such walls should not be less than 20 inches in thickness.

In the case of brick buildings the walls of ordinary stables

are frequently only one brick or 9 inches thick; but for good sound work it is necessary that the external walls should be not less than 14 inches thick. Much drier walls will also be obtained if they are built in cement instead of lime mortar.

The external walls of stables may also be built with what are known as hollow walls, having a $2\frac{1}{4}$-inch cavity. For general purposes the inner portion of the wall should be

Fig 2.

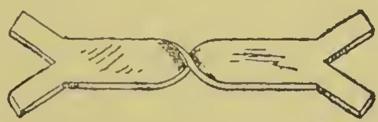


Fig. 3.

9 inches thick, the outer skin being $4\frac{1}{2}$ inches thick. The total thickness of the external walls would then be about 16 inches, including a $2\frac{1}{4}$-inch cavity or hollow space. In addition to preventing the wet driving through the walls, buildings constructed with cavity walls are warmer in winter and cooler in summer than similar buildings built with solid walls. Care must be taken that the two thicknesses of the wall are well tied together by means of iron ties

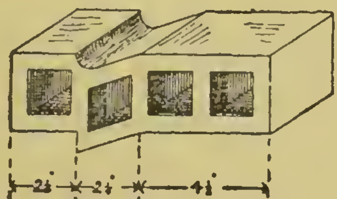


Fig. 4.

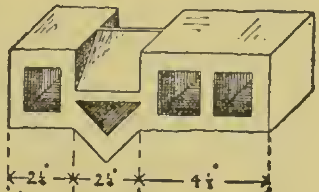


Fig. 5.

(see Figs. 2 and 3), or properly-designed bonding bricks of vitrified stoneware similar to those shown in Figs. 4 and 5. The bonding bricks or ties should be arranged chequerwise about 2 feet 3 inches apart, and every fourth course in height. Fig. 6 shows the general arrangement for a 16-inch hollow wall.

The cavity or air space should be carried round the

angles of the building, the only connection between the outer and inner wall being formed by the ties or bonding bricks. The cavity should also be carried down to a depth of about 12 inches below the damp-proof course, so that moisture may not pass from the outer to the inner wall near the ground level. Over the arch of every door and window opening a strip of 4 lb. lead, 5 inches wide, should be built $2\frac{1}{4}$ inches into the exterior wall, and project about 2 inches into the air space, the inside edge being slightly turned up.

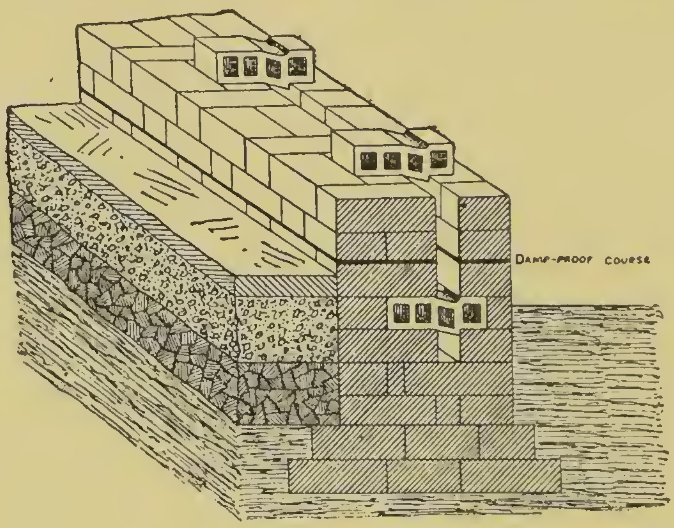


Fig. 6.

The lead strip should be carried 4 or 5 inches beyond the frames each way, so that any water penetrating the cavity may be conducted clear of the frames.

The internal or division walls should be built solid, with a minimum thickness of 9 inches. The foundations of all walls must be sufficiently deep and wide to give stability to the entire structure.

Where solid walls are built in exposed positions, any driving of rain or moisture through them may be prevented by rendering the walls on the outside with cement, or by fixing hanging tiles or slates.

A damp-proof course should be provided to the stable

walls, so as to prevent any damp or moisture from the ground rising up them by capillary attraction. The damp-proof course must be placed a few inches above the ground level and extend through the entire thickness of the wall (see Fig. 6). A double course of countess or duchess slates bedded in Portland cement, and having the upper course

FIG. 7.

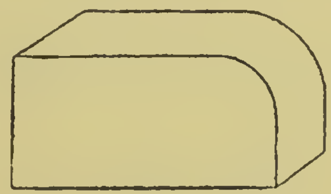


FIG. 8.

breaking joint with the lower course of slates, forms an excellent damp-proof course. A layer of asphalt $\frac{3}{8}$ inch thick is also used for the same purpose.

The external angles of all door and window openings should be well rounded. This is most satisfactorily effected by the use of specially made round-ended or bull-nosed bricks, as shown in Figs. 7 and 8 respectively. By this means any risk of injury to horses from contact with a sharp angle or arris is avoided.

CHAPTER III.

VENTILATION.

PRELIMINARY REMARKS. VOLUME OF AIR REQUIRED FOR RESPIRATORY PURPOSES. CUBIC CONTENTS AND SUPERFICIAL AREA.

Preliminary Remarks.

An ample supply of pure air is a necessity for respiratory purposes, and if animals which are confined in stables for a large portion of their existence are to be maintained in the highest state of health and efficiency, means must be adopted to ensure that the air within the building shall at all times be approximately of the same degree of purity as the external air. This is the primary object to be attained in the ventilation of all buildings; but it is also essential that the ventilation of the building shall be effected without danger or discomfort to the occupants.

The chief conditions to be fulfilled by an efficient system of ventilation are as follows, viz.:—

1. The internal air of a building must be continuously and imperceptibly changed, the vitiated air being removed and replaced with pure air in such quantities that the normal composition of the external atmosphere may be maintained within the building.

2. The continual changing of the internal air must be brought about by such means that the temperature and humidity of the air within the building are conducive to health and comfort.

The various methods adopted for ventilating buildings are broadly divided into two classes, and respectively designated *natural ventilation* and *artificial ventilation*, according to the general principles involved.

Any system by which the fresh air is supplied and the vitiated air removed by natural means, without necessitating a constant expenditure for labour or materials, is known as *natural ventilation*.

Artificial ventilation includes all the methods in which the air is renewed by means of machinery or appliances requiring a continual outlay for labour or materials to be expended in producing the amount of ventilation required.

Artificial ventilation is not adapted for ordinary purposes, owing to the cost involved in the working expenditure and superintendence of the apparatus or machinery. The liability of the working parts to get out of order is also another drawback, and its use is generally confined to large institutions and public buildings.

For stables and other buildings of a similar character, a good method of natural ventilation is the simplest and most inexpensive, and if properly designed and carried out will prove satisfactory in practice. It is therefore proposed to consider only the method of securing efficient ventilation to stables by natural means.

Volume of Air required for Respiratory Purposes.

In the process of respiration by men and animals, large quantities of oxygen are absorbed from the atmosphere, whilst carbonic acid, watery vapour, and effete organic matters are given off.

The average composition of air of normal purity is found by analysis to be as follows, viz. :—

	Parts by Volume.
Oxygen	20·96
Nitrogen	79·00
Carbonic acid	0·04
Watery vapour	Variable
Ammonia	Traces
Organic matters	Traces
Ozone	Traces
	100·00

It has been ascertained that a horse, in the process of respiration, absorbs about 2 per cent. of the oxygen contained in the air inhaled by the lungs, and gives off a nearly corresponding amount of carbonic acid—in other words, after respiration, the oxygen of the air has been reduced from 20·96 per cent. to about 19 per cent., and the amount of carbonic acid has been increased from ·04 per cent. to 2 per cent., whilst at the same time a comparatively large quantity of watery vapour and organic matter has also been given off. Such vitiated air, unless immediately restored to a similar composition as that of air in its natural state, is quite unsuitable for breathing purposes. Accordingly, the excess of organic matter and carbonic acid must be greatly reduced, and the deficient quantity of oxygen made good by the introduction and intimate commingling with large volumes of fresh air, so that the average proportions of oxygen, organic matter, and carbonic acid found in the ordinary atmosphere may be approximately maintained.

It is found that air in which the oxygen has been reduced from 20·96 per cent. to 7 per cent. is totally unfit to support life, whilst the presence of 5 to 10 per cent. of carbonic acid in the atmosphere produces fatal results. The disagreeable feeling of closeness experienced when breathing in badly-ventilated buildings is due to the excess of organic matter present in the air. As the amount of carbonic acid produced by respiration bears—for all practical purposes—a constant and direct ratio to the quantity of organic impurities present in expired air, it is usual to consider the amount of carbonic acid present in the air of inhabited buildings as indicating the measure of its purity and fitness for breathing purposes. It is now generally acknowledged that air containing more than 50 per cent. of carbonic acid than is found in the ordinary atmosphere is impure and unfit for healthful respiration. The normal quantity of carbonic-acid gas present in air is ·04 per cent. (or 4 cubic feet of carbonic-acid gas in every 10,000 cubic feet of air). Consequently the ventilation of buildings must be so arranged that at no time there shall be more than ·02 per cent of carbonic acid (or 2 cubic feet per 10,000 cubic feet of air) present in the air, in addition to the normal amount which the atmosphere contains in its natural state.

The average amount of carbonic-acid gas given off by a horse when at rest in the stable is about 2·5 cubic feet per hour. The quantity of fresh air required to be supplied per horse per hour in order that the amount of carbonic-acid gas present in the air at any time may not exceed a total of ·06 per cent. (or an addition of ·0002 per cubic foot of air) is calculated by means of De Chaumont's formula, viz.:—

$$D = \frac{E}{P}$$

Where—

D = Volume of fresh air in cubic feet per hour.

E = Amount of carbonic-acid gas exhaled per hour. (In the case of a horse this amount may be taken as 2·5 cubic feet.)

P = Maximum amount of respiratory impurity allowed per cubic foot of air. (This limit is usually fixed at ·0002.)

Or—

$$\begin{array}{c}\text{Volume of fresh air required} \\ \text{per horse per hour}\end{array} = \frac{2 \cdot 5}{\cdot 0002}$$

$$= 12{,}500 \text{ cubic feet.}$$

For general purposes, however, it is usually assumed that an allowance of 10,000 cubic feet of fresh air per horse per hour will prove sufficient; but for sick horses the allowance of air should be largely increased.

The amount here stated—viz. 10,000 cubic feet of fresh air per horse per hour—must in all cases be considered as the *minimum* quantity necessary for the maintenance of vigorous health, and it is desirable that this amount should be increased to 12,000 or 14,000 cubic feet per hour where practicable.

Cubic Contents and Superficial Area.

Having ascertained the volume of air required for respiratory purposes, it becomes necessary to consider the provision of this amount in connection with the cubic space which is available for each animal confined within the building. If a space of 10,000 cubic feet could be provided for each horse, it would only be necessary to change the internal air once an hour; whilst if 1000 cubic feet of space is the utmost that can be provided, the air must be renewed at least *ten* times within the hour in order to furnish the minimum volume of fresh air which is considered necessary for the sustenance of a thoroughly sound body.

It has been found by experiment that with ordinary

methods of natural ventilation the air of a room occupied by human beings cannot be changed oftener than three or four times an hour without a risk of creating draughts, which are both objectionable and dangerous to health. In the case of stables, the air may be changed five or six times an hour without injurious results, as horses are not so susceptible to draughts.

Taking 10,000 cubic feet as the minimum allowance of fresh air per hour per horse, and six times per hour as the extreme limit permissible for changing the air of stables, we have :—

$$\text{Minimum cubic space per horse} = \frac{10{,}000}{6}$$

$$\text{,,} \qquad \text{,,} \qquad \text{,,} \qquad = 1666 \text{ cubic feet.}$$

In the ventilation of buildings it is frequently assumed that, provided the cubic space is not decreased, the floor area may be reduced if the height of the room or building is correspondingly increased. This is a grave error, as it is essential for the purpose of respiration that adequate superficial space shall be provided. A height of 14 feet may be regarded as the extreme limit to be allowed when calculating the effective air space for stables. Any additional space above this level cannot reasonably be considered as available for breathing purposes.

It must not be understood that this represents the extreme height that stables should be built, for they may be made much loftier with advantage, but such additional height should not be regarded as affording additional effective breathing space. Any increased height would, however, tend to assist in the more thorough ventilation of the stable, whilst at the same time it would be rendered much more airy and comfortable.

It is desirable that the floor area of stables should not be less than one-twelfth the effective cubic air space; but taking

1666 cubic feet as the minimum amount of space required per horse for thorough ventilation purposes if they are to be maintained in a perfectly robust state of health, and 14 feet as the extreme height for effective breathing space, then it will be observed that—

$$\text{Minimum allowance of floor area per horse} = \frac{1666}{14}$$

$$= 119 \text{ superficial feet.}$$

In the construction of infirmary stables it is necessary that the cubic space and floor area allowed per horse should be largely increased, as in some diseases a sick horse gives off two or three times as much carbonic acid and organic matter as in a state of health.

For purposes of comparison, it may be mentioned that in the construction of French cavalry stables a space of 1750 cubic feet is allowed per horse, whilst the minimum amount of cubic space and floor area per horse to be provided in army stables in this country is laid down at 1600 cubic feet and 100 superficial feet respectively. For army infirmary stables 1800 cubic feet, with a floor area of 120 superficial feet per horse, is allowed. In the case of sick boxes this allowance is still further increased to 2500 cubic feet and a superficial area of 204 feet per horse.

The following list, showing the floor area and cubic space which have been provided in a number of stables erected in various parts of the country, recently appeared in the 'Canadian Architect and Builder.'

Although incomplete as regards the ascertained cubical contents allowed per horse, yet it affords a very useful table for reference.

It will be seen that the floor area and cubic space provided per horse in city stables of average construction as given in this table falls considerably below the standard already

STABLES ERECTED IN DIFFERENT PARTS OF THE COUNTRY.

Name.	Floor Area per Horse.	Space per Horse.
	feet super.	cubic feet.
Gifford Hall, stalls	120	1680
Ditto, loose boxes	216	3020
Wretham Hall, loose boxes	185	..
Frognall, Kent, stalls	134	..
Moreton Hall, stalls	126	..
Ditto, loose boxes	216	..
Cowesfield House, stalls	120	1080
Ditto, loose boxes	210	3780
Easton Park, Suffolk, stalls	105	..
Ditto, ditto, loose boxes	150	..
Loch Inch Castle, stalls	130	..
Ditto, loose boxes	195 to 250	..
Claremont House, stalls	130	..
Copse Hill Hunting Stables, stalls	130	..
Ditto, loose boxes	186	..
Berkswell Hall, stalls	128	..
Ditto, loose boxes	190	..
Havering-atte-Bowe, stalls	147	..
Ditto, loose stalls	120	..
Private stables at Brighton, stalls	95	..
Ditto, loose boxes	193	..
Private stables in London, stalls	84	798
Ditto, loose boxes	100	950

laid down; but, on the other hand, in the country stables mentioned, the superficial area and cubic space in most cases exceed the minimum allowance which is considered necessary for proper sanitary efficiency.

Lieut.-General Sir F. W. Fitzwygram, in his well-known

work, 'Horses and Stables,' gives the following interesting list of the cubical contents of various classes of stables erected in London, viz. :—

List of Various Stables Erected in London.	
Name.	Amount of Space allowed per Horse.
	cubic feet.
The Royal Mews	2500
Marlborough House stables	1700
South Eastern Railway Company	1540
Messrs. Reid & Co., Liquor-pond Street	1250
London, Chatham, and Dover Railway Co.	1200
Great Western Railway Co.	1116
Messrs. East, Curzon Street	1100
Messrs. Wimbush, Gillingham Street	980
Portland Place stables	950
London General Omnibus Co. (Ecclestone Place) ..	820
Stables attached to gentlemen's houses (average) ..	720
Mr. Birch's omnibus	700
Cab-horse stables (average)	550

In his remarks respecting the average small amount of cubic space found to be allowed per horse in cab stables, General Sir F. W. Fitzwygram draws attention to the fact that the horses spend nearly half the twenty-four hours in the open air, the stables being well ventilated and drained, whilst in some of them the windows are entirely removed, and the doors left wide open at night so as to secure adequate ventilation.

The same authority also gives the following list, showing the cubical contents of various military stables which have been built at different times, viz. :—

Military Stables.	
Name.	Amount of Space allowed per Horse.
	cubic feet.
Hyde Park Barracks (new) maximum	2284
Ditto ditto minimum	1452
Ditto ditto average	1781
Regent's Park Barracks (new)	1461
Aldershot Cavalry Barracks	1034
Aldershot Army Service Corps	1464
Colchester, Cavalry, open roof..	1405
Ditto, ditto, rooms over	1296
Colchester Artillery	1386
Dublin, Island Bridge	783
Dublin Royal Barracks	560
Ditto ditto Officers' (new)	1730
Glasgow (new)	1462
Hounslow	630
Manchester	798
Norwich	735
Windsor (old)	739
Woolwich (new model)	1793
York (old)	740
York (new) with room over	1122
Ditto ditto, open roof	1546

In the construction of cow-houses, the minimum amount of space to be provided for each cow should be taken at 1000 cubic feet, with a minimum floor area of one-twelfth the cubic air space, or 84 superficial feet.

CHAPTER IV.

VENTILATION—continued.

FUNDAMENTAL PRINCIPLES. VELOCITY AND VOLUME OF AIR. POSITION AND DISTRIBUTION OF AIR INLETS AND OUTLETS.

Fundamental Principles:—Important natural laws—Gaseous diffusion — Gaseous expansion—Winds — Exhaust ventilators —Velocity of winds—Montgolfier's law—Formula for ascertaining the velocity of falling bodies—Velocity of air currents—Frictional resistance—Ventilating shafts to be without bends—Another formula for computing the velocity of air currents—Table of velocity and discharge of air inlets and outlets—Difference of temperature.

Velocity and Volume of Air:—Maximum velocity of air currents permissible — Average difference of temperature and wind force available—Formula for ascertaining the volume of discharge—Table showing volume of discharge for different velocities.

Position and Distribution of Air Inlets and Outlets:—Quantity of air required—Inlets and outlets to be placed well apart—Their relative area — Regulation of air by means of valves—Additional means of ventilation.

Fundamental Principles.

All methods of natural ventilation—however much they may vary in the details of construction and arrangement—depend essentially for their proper working upon the more or less complete manner in which advantage is taken of the natural laws to which the atmosphere and other gases are subject. The two most important of these, so far as they relate to natural ventilation, are—

1. The law of gaseous diffusion.
2. The law of gaseous expansion.

With regard to the first-mentioned law of gaseous diffu-

sion, it is now well known that all gases which, when brought together, do not combine to form a chemical compound have the property of becoming intimately mixed with each other, even though they are simply allowed to remain at rest without being shaken up. The rate or velocity at which different gases diffuse has been found to be proportional to their respective densities or weights. From experiment it has been ascertained that *the velocity of diffusion of gases is inversely proportional to the square root of their respective densities.* For instance, the diffusive power of hydrogen gas is *four* times greater than that of oxygen, the latter gas being *sixteen* times heavier than hydrogen. This property of gaseous diffusion is important, inasmuch as it tends to produce an equal distribution of the gases given off in the process of respiration; but owing to the comparatively slow rate at which the gases diffuse, it is totally inadequate in itself for purposes of ventilation.

The most valuable natural force which is utilised in the ventilation of buildings is that of gaseous expansion. Air, like all gases, increases in bulk when heated and diminishes when cooled. The hot air as it expands, becomes lighter, and ascends, whilst the surrounding cold air, being of greater specific gravity, descends to take its place.

The continual and varied movements of the atmosphere called *winds* are essentially due to the last-mentioned cause, and it is on this wind force, together with the air currents caused by the difference of temperature between the air of inhabited buildings and the external atmosphere, that the efficiency of any system of *natural* ventilation will chiefly depend.

In the consideration of wind force as a means of ventilating buildings, the first thing that will be observed is the inconstant nature of the force available. At one time a strong breeze may be blowing, whilst at another period scarcely any motion is noticeable in the air. It has, however, been found that some movement is always present in

the atmosphere, even on what may appear to the casual observer to be a perfectly calm day. The velocity of the wind may vary in degree from a hurricane moving at the rate of 100 miles an hour to an imperceptible air movement of 1 mile per hour. The average velocity of the wind in

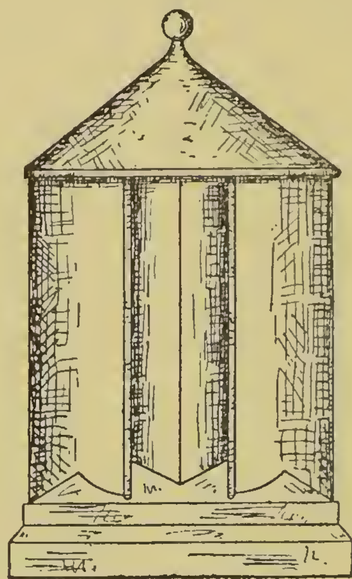


FIG. 9.

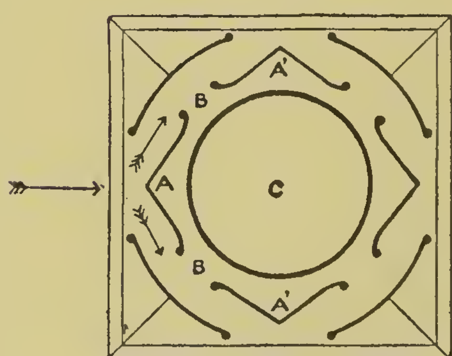


FIG. 10.

this country is from 7 to 12 miles per hour, and it will seldom be found to be less than 4 miles an hour.

Advantage is taken of this continuous but variable wind-force in order to extract the internal air of the building by fixing some form of extracting cowl or hood on the vitiated-

air outlets. For this purpose numerous descriptions of automatic exhaust ventilators have been devised and patented, so as to remove the air of buildings by aspiration. Some forms of exhaust ventilators have revolving heads which actuate an archimedean screw arrangement within the ventilator, whilst others are designed without any movable parts. The latter description—known as *fixed* aspirating ventilators—are now most commonly used. These essentially consist of a number of baffle or intercepting plates, so arranged that the velocity of the wind passing over and around the ventilator withdraws the internal air by creating a partial vacuum in the ventilating shaft, which is being continuously supplied with air from within the building.

Figs. 9 and 10 show the elevation and plan of the general construction of an exhaust ventilator with vertical baffle plates. The wind on entering the ventilator in the direction of the arrow, is deflected by the baffle plate A, and in passing the openings B B, between the baffle plate A and the adjacent baffle plates A′A′, withdraws the internal air by creating a partial vacuum within the ventilating tube C, which is constantly being supplied with air from the interior of the building. In this manner the vitiated air is continuously drawn off by the force of the wind so long as the supply of fresh air to the building is being maintained.

A similar elevation and section of an exhaust ventilator with horizontal baffle plates or diaphragms is shown in Figs. 11 and 12, the principle of which will be readily understood from the explanation just given. Should any rain or snow penetrate the ventilator, it is collected in the safe or tray T, and discharged on the outside by means of the small pipe P, as indicated in the section (see Fig. 12).

A good automatic exhaust ventilator should, under favourable conditions, exert an extracting power of about *half* the velocity of the wind—that is, a wind moving at 7 miles an hour, or about 10 feet per second, acting on an exhaust ventilator of good design, will extract the internal air at the

rate of 5 feet per second, provided that adequate fresh-air inlets have been fixed, and that no loss is incurred through excessive friction in the ventilating shaft itself.

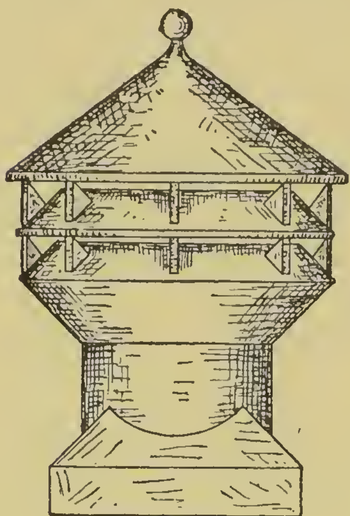


FIG. 11.

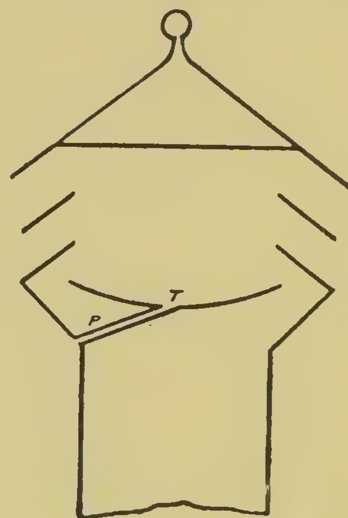


FIG. 12.

The following table shows the velocity of various winds in miles per hour and feet per second.

TABLE OF VELOCITY OF WINDS.

Description of Wind.	Miles per Hour.	Feet per Second.
Imperceptible	1	1·46
Perceptible	5	7·33
Gentle	7	10·26
Light breeze	10	14·66
Strong breeze	20	29·33
Stormy breeze	40	58·66
Gale	60	88·00
Storm	80	117·33
Hurricane	100	146·66

It now becomes necessary to consider the action of air

currents caused by the difference of temperature between the air of inhabited buildings and the external atmosphere, so far as this variation of temperature may be brought to bear upon the ventilation of buildings.

In this country the internal air of inhabited buildings is almost invariably higher in temperature than the external air, owing to the heat thrown off in the process of respiration, and from other causes. The internal and warmer air, being of lighter specific gravity, tends to ascend, whilst the external colder and consequently denser, heavier air—obeying the laws of gravitation—presses downwards to take its place. According to the law of falling bodies—known as Montgolfier's law—the velocity of a body falling freely from a state of rest constantly increases during the whole period of its descent. This acceleration of velocity is due to the action of gravity, and it has been found that a body starting freely from a state of rest will have acquired a velocity of nearly 32·2 feet per second at the end of the first second. From numerous pendulum observations taken in various places, it is found that this value or coefficient of gravitation is not strictly correct for all places, as, owing to the earth's form, the action of gravity varies slightly at different points of the earth's surface. Thus, at sea level at the equator this value is found to be 32·088; at the poles it is 32·253. In the latitude of London the coefficient of gravitation is 32·191; at Paris 32·182; whilst at Manchester it is 32·196; and at Edinburgh 32·203; but for all practical purposes it is usual to consider the value of the acceleration due to gravity as 32·2 feet per second.

The general statement of the physical law respecting the velocity of falling bodies is as follows, viz.:—

$$
\begin{aligned}
V &= \sqrt{2\,G\,S} \\
&= \sqrt{2 \times 32{\cdot}2 \times S} \\
&= \sqrt{64{\cdot}4 \times S} \\
&= 8{\cdot}025\,\sqrt{S}
\end{aligned}
$$

Where—

V = Velocity in feet per second acquired in falling through a given space.

G = Acceleration in feet per second due to gravitation = 32·2 feet per second.

S = Space fallen through in feet.

In order to obtain the velocity of the descent of the colder air—and conversely, the rate of ascent of the warmer air—it is necessary to ascertain the vertical distance in feet between the fresh-air inlet and the extreme point of discharge of the foul-air outlet, together with the amount of expansion due to the difference of temperature between the internal and external air, and to substitute these values for S in the foregoing equation. From numerous experiments it has been ascertained that air expands ·002 of its volume for every rise of 1° Fahr. in temperature.

Let—

h = Vertical distance in feet between the fresh-air inlet and the top of the foul-air outlet.

t = Excess of temperature of the internal air over the external air in degrees Fahr.

The preceding equation then becomes—

$$V = 8{\cdot}025\sqrt{h\,t \times {\cdot}002}.$$

It will be observed that no allowance has been made in this formula for the great loss of velocity to which air currents are subject when passing through orifices or flues. For practical ventilation purposes it is therefore necessary to remember that the velocity of the air currents will be greatly retarded by friction between the flowing air and the sides of the inlet or outlet flues.

In the construction of ventilating flues and shafts, the following points respecting the resistance offered by friction should be noticed, viz.:—

1. *The frictional resistance varies directly as the length of the tube or shaft.* For instance the resistance offered to a current of air passing through a tube 10 feet long is *twice* the amount which would be obtained in a precisely similar tube 5 feet long.

2. *The frictional resistance varies directly as the square of the velocity of the air current.* Thus, a current of air passing through a tube with a velocity of 2 feet per second will meet with *four* times the amount of frictional resistance which would be offered to an air current passing through the same tube with a velocity of 1 foot per second.

3. *The frictional resistance varies inversely as the diameter or area of the tube or shaft.* A tube, 3 feet in diameter, would offer *one-third* the resistance to that of a similar tube 1 foot in diameter, the velocity of the air current in both cases being the same. For this reason it is desirable that the air-way of exhaust ventilating shafts may be as large as practicable.

Ventilating shafts of circular section give the best results, as they afford the greatest area for the passage of air currents with the smallest amount of exposed frictional surface. It is also important that angles or bends should be avoided as far as possible, as the velocity of an air current is greatly reduced thereby. For all practical purposes it is found that every right-angle bend within a ventilating flue or shaft reduces the velocity of the current by one-half. Consequently a current of air having a velocity of 5 feet per second, on entering a ventilating flue with one right-angle bend, would (irrespective of any loss of velocity due to friction with the sides of the flue) be reduced to $2\frac{1}{2}$ feet per second immediately after passing the bend, whilst with two right-angle bends the velocity of the current, after passing the second bend would only be about $1\frac{1}{4}$ feet per second, and in the case of three bends there would practically be no current at all, where the initial velocity was only 5 feet per second.

The internal surfaces of the ventilating flues should be

perfectly smooth, so that the loss of velocity due to friction may be reduced to a minimum. As a broad comparison, it may be mentioned that the velocity of an air current through a flue having rough sides has been found to be only half that obtained in a flue of similar size and length when constructed with smooth internal surfaces.

To obtain the most satisfactory results, all ventilating shafts should therefore be quite smooth inside, straight, and without any angles or bends. Where angles are a necessity, they should be well rounded. Even when these conditions are complied with as far as possible, a certain amount of friction, and consequent loss of velocity, is unavoidable. In order to allow for this loss of velocity due to friction a deduction varying from $\frac{1}{4}$ to $\frac{1}{2}$ (according to the local circumstances of the case) is usually made from the results given by the foregoing formula. For ordinary purposes, the net resultant velocity thus obtained will be found to afford sufficiently reliable results for straight flues of average length and section.

Where more accurate results are required it is necessary to take into consideration the length and sectional area of each flue. The following formula may then be used with advantage, viz.:—

$$V = \sqrt{\frac{\cdot 13\,D\,H\,T}{D + C\,L}}.$$

Where—

D = diameter of flue in feet for flues of circular sections, or—
= the square root of the sectional area of flue in square feet for square or rectangular sections.

L = length of flue in feet.

C = Coefficient of friction, varying for surfaces of different materials, or—
= ·02 for clean glazed earthenware pipes or flues.
= ·03 for wood shafts or flues.
= ·06 for flues coated with soot.

H = vertical distance in feet between the fresh-air inlet and the top of the foul-air outlet.
T = excess of temperature of the internal air above that of the external air in degrees Fahr.
V = velocity of air current in feet per second.

The following table (page 34) shows the velocity and volume of discharge of air inlets and outlets for various differences of temperature and height, as given by the previously mentioned formula ($V = 8 \cdot 025 \sqrt{h\ t \times \cdot 002}$), after deducting one-fourth for loss by friction.

The average difference of temperature between the internal and external air may be taken at 10° Fahr. It will be seen from the table given, that a difference of level of 35 feet between the fresh-air inlet and foul-air outlet, together with a difference of temperature of 10° Fahr., would create an air current having a velocity of about 5 feet per second.

In winter, when the difference of temperature between the internal and external air would probably exceed 10° Fahr., the velocity of the incoming cold air would be proportionately increased, whilst during the hottest part of the summer, when the difference of temperature would sometimes be less than 10° Fahr., the velocity of the fresh air entering the building would be correspondingly decreased. Under these circumstances, it is desirable that provision should be made so that an increased amount of fresh air may be admitted in the summer by means of additional ventilating openings (this may be effected by opening the windows); whilst in winter precautions must be taken to avoid the injurious effects which any unguarded cold draughts might have upon the horses, consequent upon the increased velocity at which the cold external air may enter the building.

VELOCITY AND VOLUME OF DISCHARGE OF AIR INLETS AND OUTLETS FOR VARIOUS DIFFERENCES OF TEMPERATURE AND HEIGHT, AFTER DEDUCTING ONE-FOURTH FOR LOSS BY FRICTION.

Difference of Level between Fresh-Air Inlet and Foul-Air Outlet.	Excess of Temperature of Internal Air over the External Air.	Velocity of Discharge.	Volume of Discharge per square inch of Inlet and Outlet.
	Degrees Fahr.	Feet per second.	Cubic feet per hour.
5 feet.	5°	1½	37
	10°	2	50
	15°	2¼	56
	20°	2¾	69
10 feet.	5°	2	50
	10°	2¾	69
	15°	3¼	81
	20°	3¾	94
15 feet.	5°	2¼	56
	10°	3¼	81
	15°	4	100
	20°	4¾	119
20 feet.	5°	2¾	69
	10°	3¾	94
	15°	4¾	119
	20°	5½	137
25 feet.	5°	3	75
	10°	4¼	106
	15°	5¼	131
	20°	6	150
30 feet.	5°	3¼	81
	10°	4½	113
	15°	5¾	144
	20°	6½	163
35 feet.	5°	3½	88
	10°	5	125
	15°	6	150
	20°	7¼	181
40 feet.	5°	3¾	94
	10°	5½	137
	15°	6½	163
	20°	7½	188

Velocity and Volume of Air.

The maximum velocity permissible for the renewal of air within any building may be taken as 5 feet per second. With a well-designed system of natural ventilation such a velocity imparted to the incoming or outgoing air should not create an objectionable or dangerous draught in any part of the interior.

For purposes of natural ventilation in this country, it is considered that during a period of at least nine months of the year it may be safely anticipated that there will be a difference of not less than 10° Fahr. between the temperature of the internal and external air of any occupied building, and also that for the greater part of the year, the minimum velocity of the wind may be taken at 7 miles per hour.

On reference being made to the table of velocities (for air currents generated by various differences of temperature and heights) previously given, it will be found that a difference of level of 35 feet between the air inlet and outlet, together with a difference of temperature of 10° Fahr., will create an air current of 5 feet per second, after deducting the usual allowance for loss by friction. It has also been shown that an exhaust ventilator of good design is capable of extracting the internal air of a building at a velocity of 5 feet per second when the wind is travelling at the rate of 7 miles per hour. Only on very rare occasions will it be found that one or other of these natural agents are not available for ventilation purposes, whilst for the greater portion of the year it is safe to assume that, in some degree, both forces will be in operation at the same time. By the utilisation of the wind force, together with the heat force afforded by the difference of temperature between the internal and external air, it may therefore reasonably be considered that a velocity of 5 feet per second is obtainable throughout the whole of the year for the ventilation of stables and other similar buildings.

The velocity of the air currents having been determined, the volume of discharge per hour for every square inch of fresh-air inlet and foul-air outlet is readily calculated from the formula—

$$D = V \times A.$$

Where—

D = Discharge in cubic feet per hour.
V = Velocity in feet per hour.
A = Sectional area of inlet or outlet in feet.

The following table shows the volume of discharge per hour per square inch of ventilating inlet and outlet for currents of air moving at different velocities, viz. :—

TABLE OF DISCHARGE PER SQUARE INCH OF INLET AND OUTLET FOR AIR CURRENTS FLOWING AT DIFFERENT VELOCITIES.

Velocity of Air Current.	Volume of Discharge per square inch of Inlet and Outlet.
Feet per second.	Cubic feet per hour.
1	25
2	50
3	75
4	100
5	125
6	150
7	175
8	200
9	225
10	250

By reference to the above table it will be seen that every square inch of fresh-air inlet and foul-air outlet provided in the building will, under the conditions previously mentioned, admit and discharge 125 cubic feet of air per hour at a velocity of 5 feet per second.

Position and Distribution of Air Inlets and Outlets.

It has already been shown that for hygienic purposes it is desirable that an allowance of 1666 cubic feet of stable space should be provided per horse, together with such means of ventilation that 10,000 cubic feet of fresh air per horse per hour is admitted into the building, so that the air may be completely changed six times every hour. As each square inch of inlet and outlet under normal conditions admits and discharges 125 cubic feet of air per hour at a velocity of 5 feet per second, it follows that the total minimum area of inlet and outlet to be provided will amount to 80 square inches per horse. In all cases, however, where possible, it is better to make provision for a minimum area of 100 square inches for every horse.

It now remains to determine the position and total relative proportions of the fresh-air inlets and foul-air outlets which are found necessary for carrying these principles of ventilation into practice, so that thoroughly satisfactory results may be obtained. To procure the best results from any given difference in the specific gravity of the internal and external air, the inlets for the cold fresh air should be placed at a comparatively low level, the vitiated or heated air outlets being situated at the highest points of the building. The inlets and outlets should be placed as far apart as practicable from each other, so that the air may be completely diffused within the building, instead of merely passing direct from the inlet to the outlet. The fresh-air inlets should be comparatively numerous, and so arranged that the air on entering is at once thoroughly distributed throughout the building in order to prevent stagnation of the internal air at any point. In this respect it is necessary that every corner of the building should receive due consideration.

It is sometimes suggested that the total area of the outlets should slightly exceed the total area of the inlets, so as to allow for the increase of volume which takes place in

the case of cold air after admission to a warm building; but to ensure the most satisfactory results in a system of natural ventilation, it is desirable that the total area of the fresh-air inlets should *exceed* the total area of the foul-air outlets. This is necessary in order to avoid, as far as possible, any risk of down-draught, and also to compensate for the extra friction caused by the distribution of the total inlet area over a large number of separate inlets, each having a relatively small area. For these reasons, it is better that the total area of the fresh-air inlets should be one-fourth greater than that of the foul-air outlets. Taking the minimum total area of foul-air outlets per horse at 80 square inches, the minimum total area of the fresh-air inlets should therefore be 100 square inches; or, in situations where a minimum total area of foul-air outlets of 100 square inches per horse can be provided, it should be so arranged that the fresh-air inlets have a total area of 125 square inches.

Whilst the total inlet area is distributed over a large number of separate orifices, the total outlet area should be provided by means of a few large-size extracting shafts judiciously placed for the easy and thorough removal of the heated and impure air. The lower end of each extracting shaft should be enlarged so as to form a trumpet-shaped mouth, in order to assist the passage of the outgoing current of air. When the best possible results are required to be obtained from the extracting shafts, they should be enclosed with wood, felt, or some other non-conductor, so as to prevent any appreciable loss of heat from the ascending warm air.

The ventilation of buildings is sometimes designed so that the ingress and egress of the air may be regulated by means of valves; but in many cases it is desirable that the inimum amount of inlet and outlet area mentioned should be so ordered that it is practically constant and incapable of being greatly reduced. In places where the admission of air can be controlled, it is frequently found that the stablemen

will close every possible opening so as to produce a feeling of warmth within the stable, without considering the vitiated condition of the internal air that necessarily follows, or the evils that are produced thereby; the result being that a most unhealthy atmosphere must consequently be breathed by the animals confined therein.

In addition to the ordinary provision made for permanent ventilating purposes, all the windows—together with the fanlights over the doors—should be made to open, so as to give additional means of ventilation if necessary at any time.

CHAPTER V.

VENTILATION—continued.

INLET AND OUTLET VENTILATORS.

INLET VENTILATORS.

MANUFACTURERS of these appliances have from time to time introduced modifications in their general arrangement and design; but whatever the means adopted, the primary object to be performed by all inlet ventilators is the admission of cold air into a building without creating an objectionable draught. Essentially, this is effected in a somewhat similar manner in all of them—that is, by the construction of a traverse or turning within the ventilating flue; or the provision of baffle plates in the ventilator, so that the velocity of the incoming current is broken at the point of entry, and the air more gently diffused within the building.

In certain classes of stables and cow-houses the current of air is allowed to enter direct by means of a continuous ventilating course, consisting usually of a series of glazed stoneware perforated air bricks. Figs. 13 and 14 show ventilating bricks suitable for this purpose: they may be obtained in different sizes to suit any thickness of wall.

Fig. 15 is a section through a louvred ventilator which allows the air to enter direct, but the current is deflected upwards by passing through a number of louvres on the

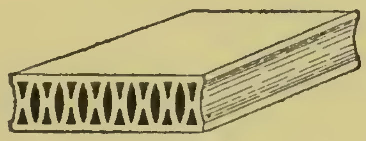


Fig. 13.

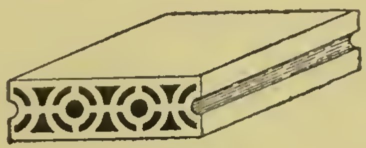


Fig. 14.

inside. The louvres can be obtained either fixed or hinged according to requirements.

Generally, however, the velocity of the incoming fresh air is broken by means of a traverse within the flue, or by an arrangement of one or more baffle plates. A simple form of

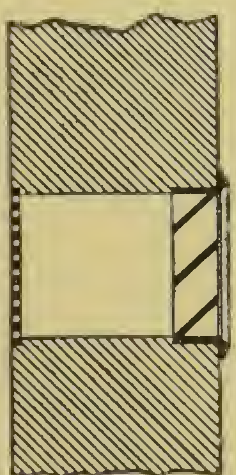


Fig. 15.

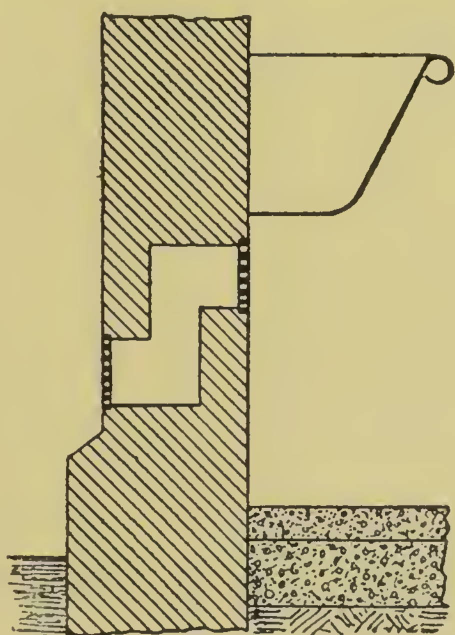


Fig. 16.

fresh-air inlet is shown in Fig. 16, and consists of an internal and external air brick or grating connected with a traverse or drop opening formed within the thickness of the wall.

In some cases the outer air grating is fixed at a higher level than the inner one, the traverse or drop opening being reversed.

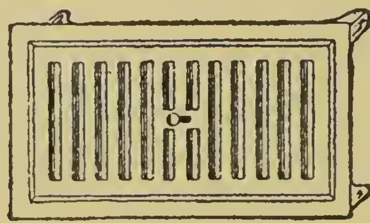


Fig. 17.

If desired, the volume of air can be regulated by providing a hit-and-miss ventilating grating on the inside, as shown in Fig. 17; but, generally, it is advisable *to* arrange that the

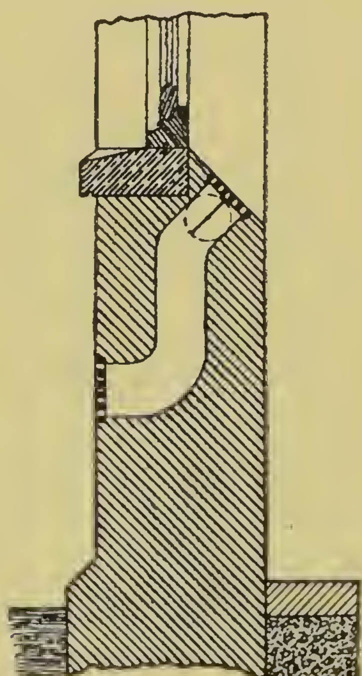


Fig. 18.

admission of fresh air to stables should be as nearly as possible constant, the means of regulation of the air currents being confined within narrow limits. The inlet flue should

be of sheet iron when built in hollow walls, or rendered smooth in cement for solid walls, the external air grating being hinged in all cases, so as to provide means of access for cleaning the flue at any time.

A form of inlet ventilator known as a window-sill inlet is shown in Fig. 18; it is designed to admit the air in an upward, instead of a horizontal direction, but is more liable to become choked with dirt, hay seeds, &c.

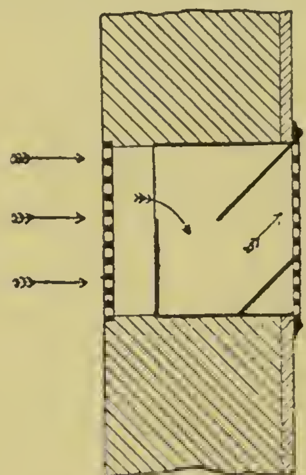


FIG. 19.

A fresh-air flush inlet ventilator provided with baffle plates is shown in Fig. 19. Air inlets of this description may also be obtained with or without a regulating valve.

Fig. 20 is a section through what is known as the Tobin tube fresh-air inlet ventilator. The advantage of this type of ventilator is that the air may be discharged in a vertical direction at any desired height within the building, whilst the external opening may be arranged near the ground level, so that the maximum difference of level between the inlet of the fresh air and the outlet of the foul air is obtained. Although Fig. 20 shows the common form of Tobin tube, yet it is very unsuitable for use in stables, owing to its projection from the wall. In stable construction nothing should be allowed to project beyond the face of the walls unless

absolutely unavoidable, in order to minimise any risk of injury to the horses.

A modification of Tobin's tube inlet ventilator, which is suitable for stable buildings, is shown in Fig. 21. The external air grating should be hinged, so as to admit of the tube being periodically cleaned.

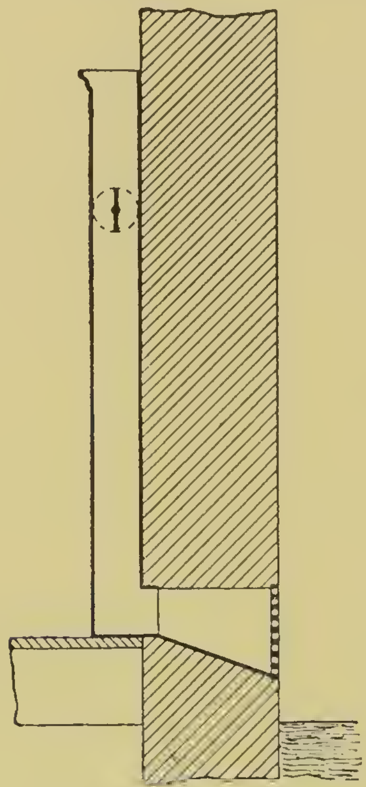


FIG. 20.

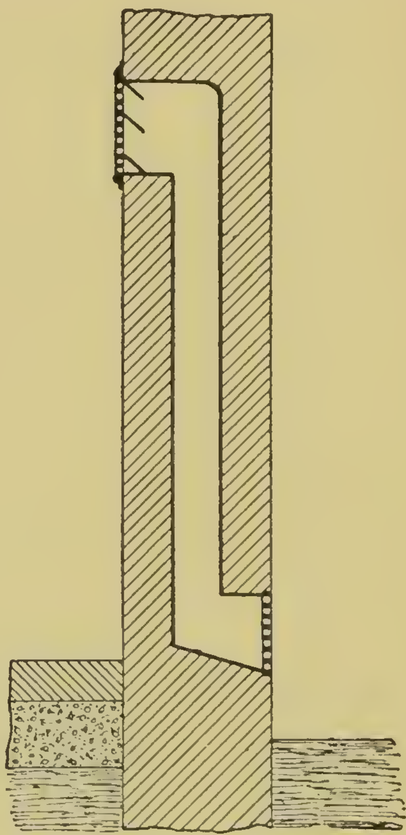


FIG. 21.

Another adaptation of the Tobin inlet tube, as made by Messrs. Musgrave and Co. (from a suggestion by Mr. Waterhouse, R.A.), is shown in Figs. 22 and 23. It is eminently suitable for admitting fresh air at the head of each stall, and is known as a ventilating stall division. As will be seen from the plan and elevation given, the portion of the stall division near the wall is made in the form of an elongated tube. The fresh air is admitted near the bottom through an

external air grating, and discharged into the building in a vertical direction at the top of the division. If desired, the quantity of air admitted may be controlled by means of a regulator within the tube.

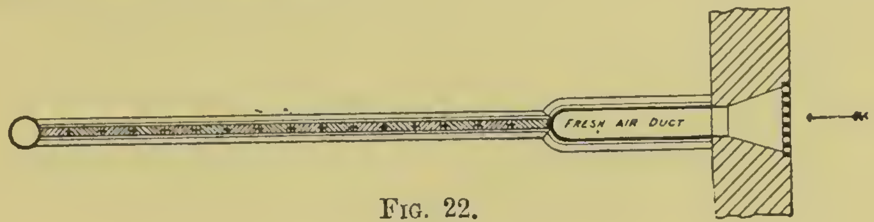


Fig. 22.

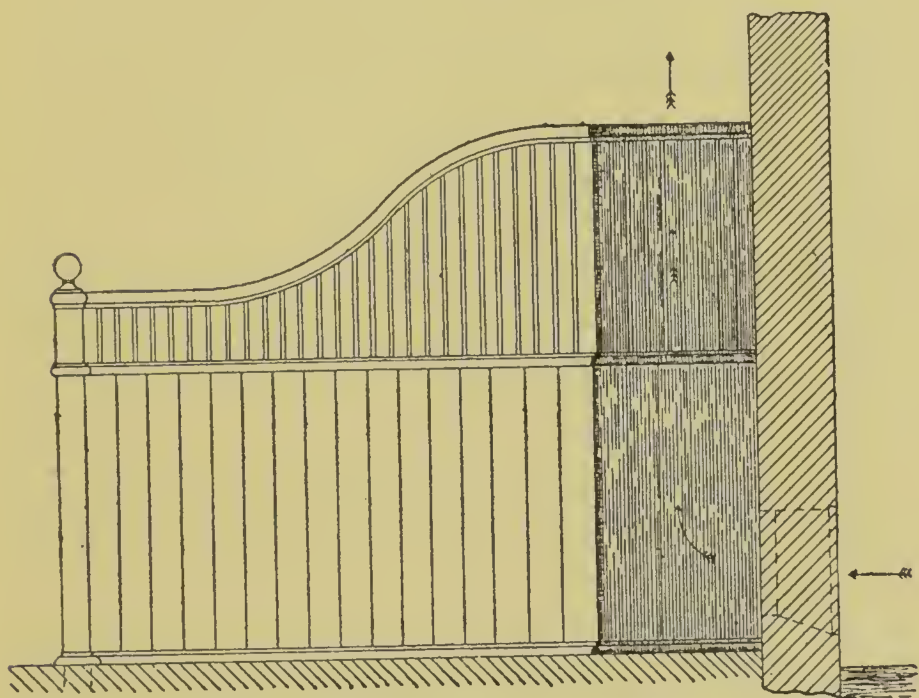


Fig. 23.

Stables are sometimes ventilated by means of what are known as ventilating heel posts, as shown in Fig. 24. The defect of this method of ventilation is the comparatively great length of inlet shaft, and the consequent retardation of the air current owing to excessive friction, whilst the air way of the shaft is liable to be blocked with accumulations of

dust, hay seeds, &c., which cannot be conveniently removed. Where the ventilation is carried out in this manner, the

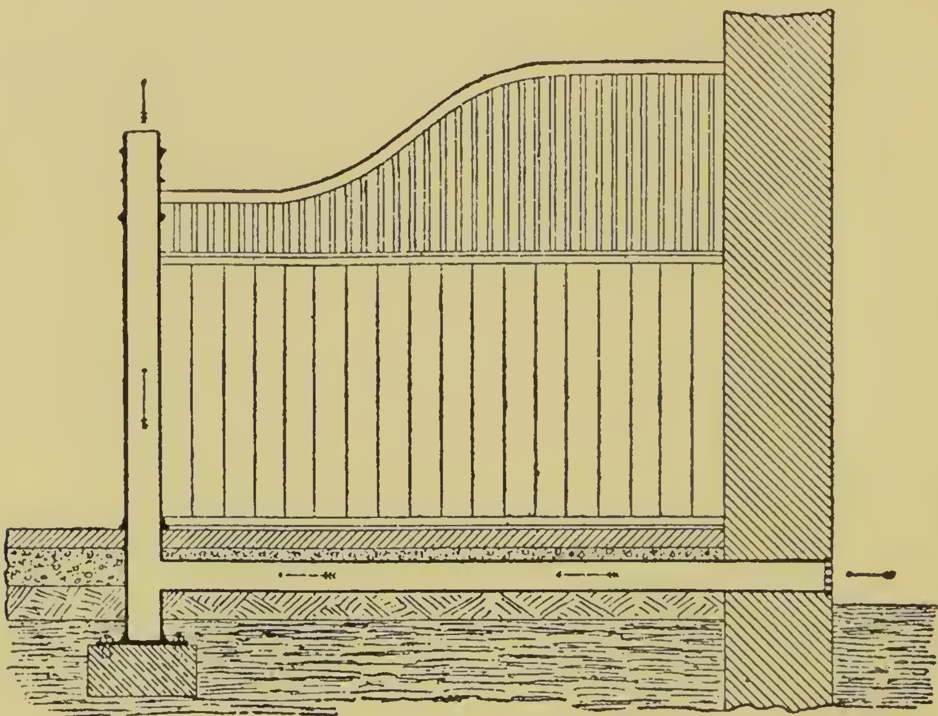


Fig. 24.

renewal of the air within the building is, as a rule, not so thoroughly effected as in the case of well distributed wall inlet ventilators.

Outlet Ventilators.

The simplest and cheapest form of outlet ventilator for stables with an open roof consists of one or more openings arranged near the ridge. Fig. 25 is a section through a ventilating ridge as sometimes adopted for stables of cheap construction. The warm vitiated air escapes through the open spaces between the small rafters; but such means are quite inadequate for thorough ventilation, whilst the rain and snow are also apt to be driven into the building through the unprotected openings.

Fig. 26 is an improvement upon the previous method, the height of the openings being increased and the space filled in with louvres. The illustration shows a section

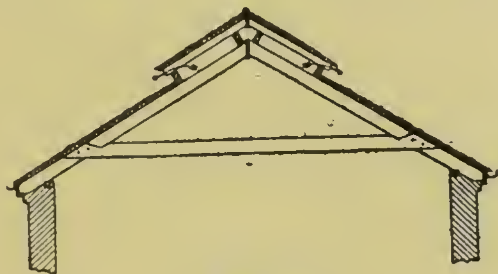


Fig. 25.

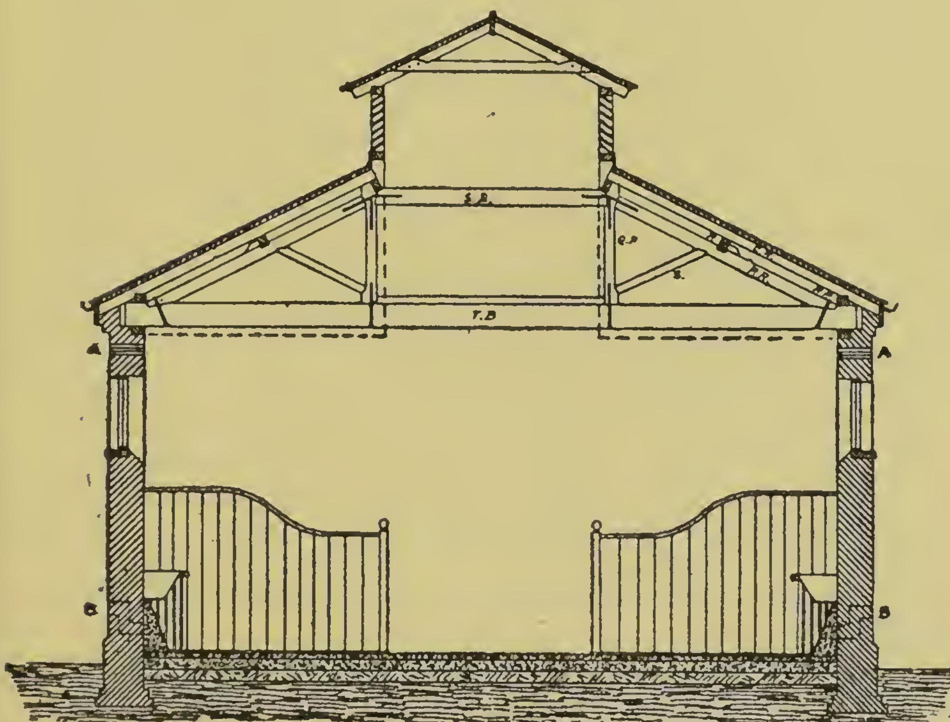


Fig. 26.

through an open queen-post roof with a continuous ridge louvred ventilator. Occasionally a portion of the roof is ceiled on the under side of the tie beams and on the inner side of the queen posts, as indicated by the dotted lines.

Sometimes, instead of the roof ventilation being continuous, it is divided into a series of small ridge ventilators placed at intervals, as in Fig. 27.

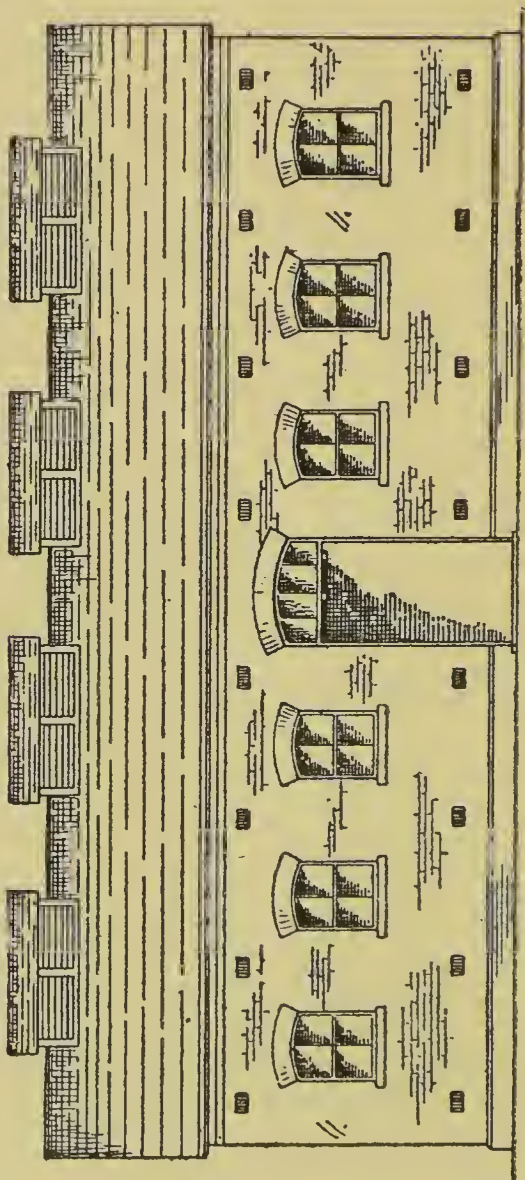


Fig. 27.

In another arrangement, the louvred ventilators take the form of small dormers on each side of the ridge, as shown in Fig. 28. The louvres themselves may be fixed, or constructed to open and close. Where the latter method is

adopted they should be so designed that whilst either side may be opened or closed at will, yet under no circumstances should both sides be capable of being closed at the same time.

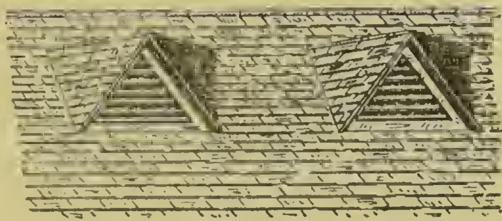


Fig. 28.

Fig. 29 is a section through an iron roof having continuous ridge ventilation and fitted with iron louvres.

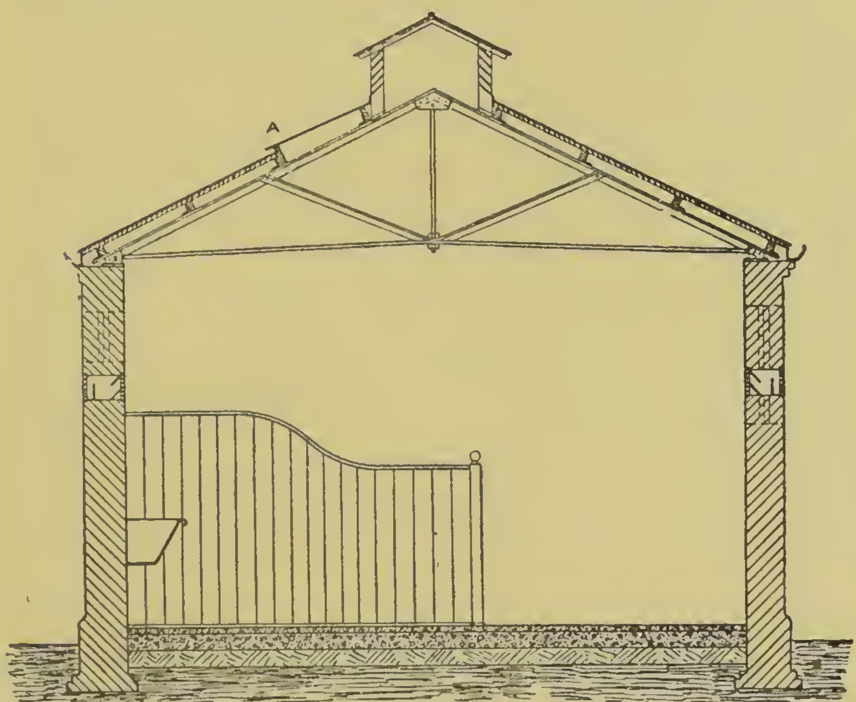


Fig. 29.

The principal objection to the ordinary methods of louvred ridge ventilation is due to the fact that there is a tendency to down-draught, whilst in very high winds the

rain and snow are driven into the building; but if the louvres are arranged so that those on either side may be closed (according to the direction of the wind), and sufficient fresh-

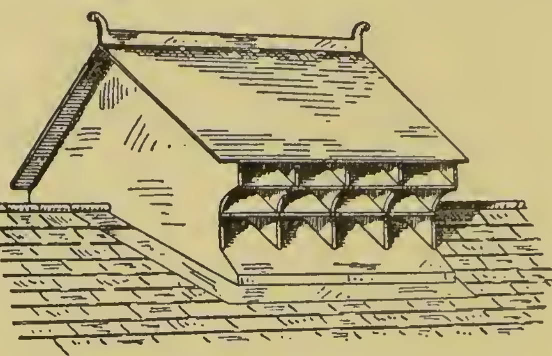


Fig. 30.

air inlet area provided, the deleterious effects of down-draught and driving rain may in a great measure be prevented.

Instead of adopting the common form of louvred ridge

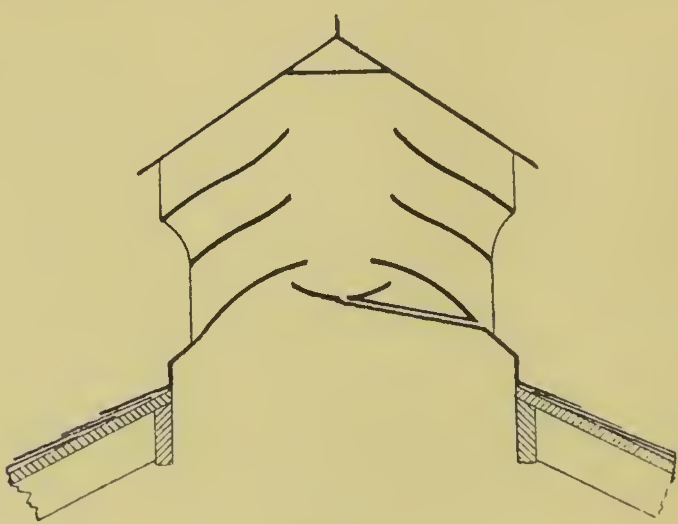


Fig. 31.

ventilator, a type of exhaust ventilator similar to that shown in Figs. 30 and 31 may be used with advantage, the efficiency of the ventilation being thereby increased.

Perhaps the most satisfactory form of outlet ventilating appliance is a well-designed *turret* exhaust ventilator, so arranged as to be freely acted upon by the wind when blowing from any point of the compass. In this respect it will be seen that longitudinal ridge ventilators are inferior, inso-

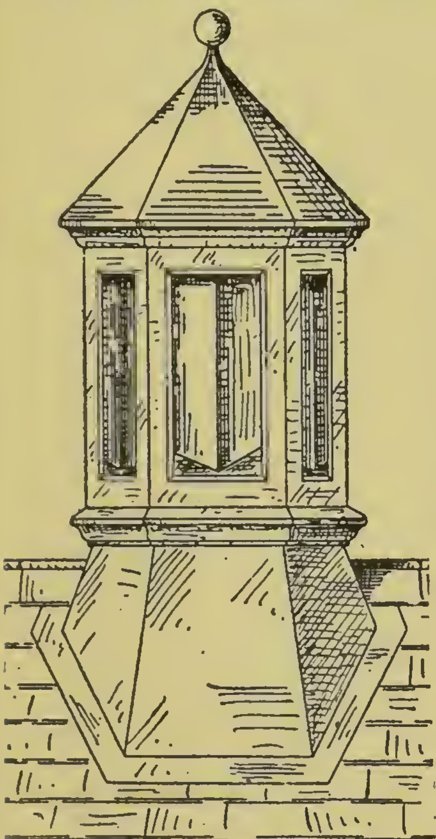


FIG. 32.

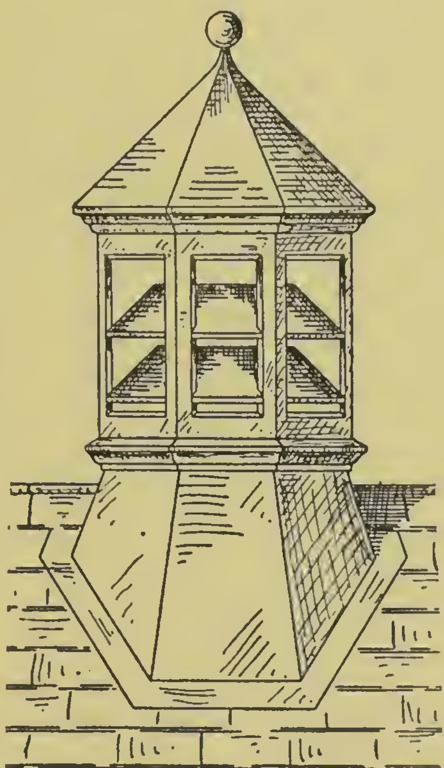


FIG. 33.

much that the ends are usually closed, so that the direct action of the wind when blowing from certain quarters is virtually lost.

A good type of turret exhaust ventilator should be capable of producing a continuous up-draught in any wind, at the same time being perfectly weather proof and impervious to driving rain or snow, and noiseless in action. In addition, the exhaust ventilator should be designed to provide, as far

as possible, an unrestricted air passage of large area, so that, independently of the wind, a free exit may be given to any current of air which may be created by an excess of temperature of the internal over the external air.

Fig. 34.

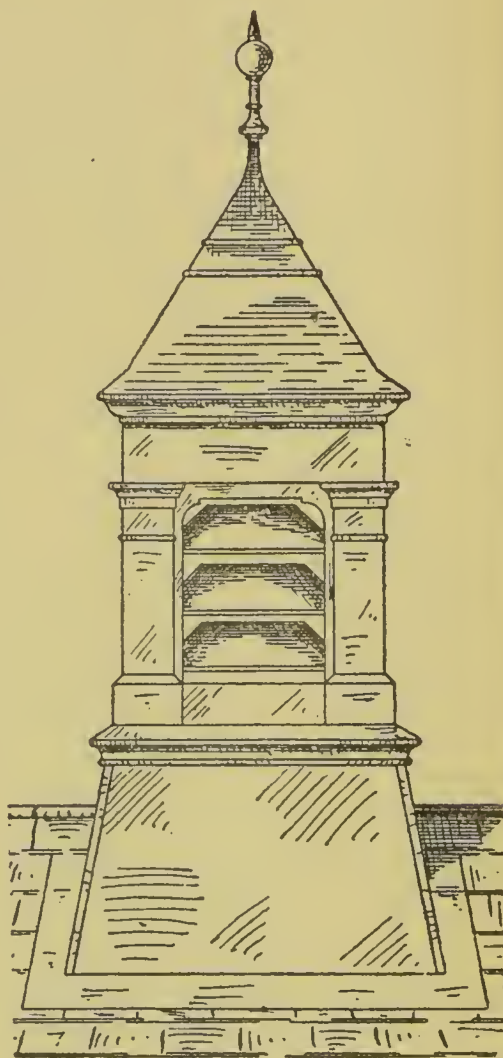


Fig. 35.

Figs. 32 and 33 are sketches showing exhaust ventilators of a simple and inexpensive form, fitted with vertical and horizontal baffle plates respectively. Ventilators of this description may be made more or less ornamental in appear-

ance by being enclosed within a specially designed turret or flêche, as indicated in Figs. 34 and 35.

In situations where a turret ventilator is undesirable on architectural or other grounds, sufficient outlet ventilation may be obtained by the use of what are known as *concealed* or *invisible* roof ventilators. Fig. 36 is a common form of so-called hidden ventilator. The wind, entering the venti-

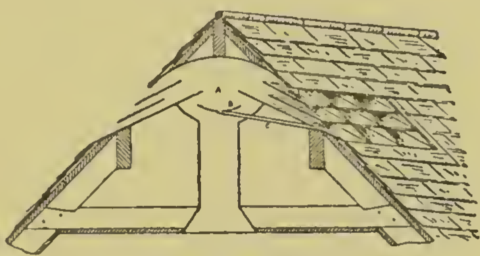


Fig. 36.

lator on one side of the roof, passes over the opening A and out at the other side, at the same time withdrawing a portion of the internal vitiated air with it. Any water driven into the ventilator is caught by the tray B, and discharged on to the roof by means of a small tube C. Concealed ventilators are not so efficient as turret ventilators, as they are not so freely exposed to the action of winds. For this reason the latter are to be preferred.

CHAPTER VI.

VENTILATION—continued.

THE GENERAL DESIGN.

The General Design :— Ventilating stall partitions arranged with Tobin tube and foul-air flues—Wall inlet ventilators with louvred outlet ventilators at ridge—Ventilation of army stables—Arrangement for a single row of stalls—Stables with a double row of stalls—Windows to be made to open.

Having considered the essential principles which should govern the construction of any system of natural ventilation, and also the various forms of ventilating appliances which have been found to give the best practical results, it becomes necessary to determine the most satisfactory disposition of the fresh-air inlets and foul-air outlets in relation to the building as a whole, and for the comfort of the animals confined therein.

Fig. 37 is the section of a stable in which the fresh air is admitted at the head of each stall by means of a ventilating stall partition, as already described and illustrated (see Figs. 22 and 23) in detail, together with a Tobin fresh-air inlet tube (see Fig. 21) fixed in the front wall of the stable directly opposite each stall partition. The warm vitiated air is removed by means of one or more foul-air flues (according to size of the stable) passing vertically through the roof, and terminating in a suitable exhaust turret ventilator.

A modification of this arrangement is shown in Fig. 29, in which wall inlet ventilators are fixed opposite each other

in the front and back walls of the stable, near each stall partition. By this means an ample supply of fresh air may be introduced near the head and also at the rear of each stall. The respired air escapes through the louvred ventilator at the apex of the roof. The relative positions of the windows are shown by the dotted lines.

In the ventilation of army stables, the building is usually provided with an open roof and continuous ridge ventilation for the exit of vitiated air. The ridge ventilators are in some instances arranged so as to allow of their being closed

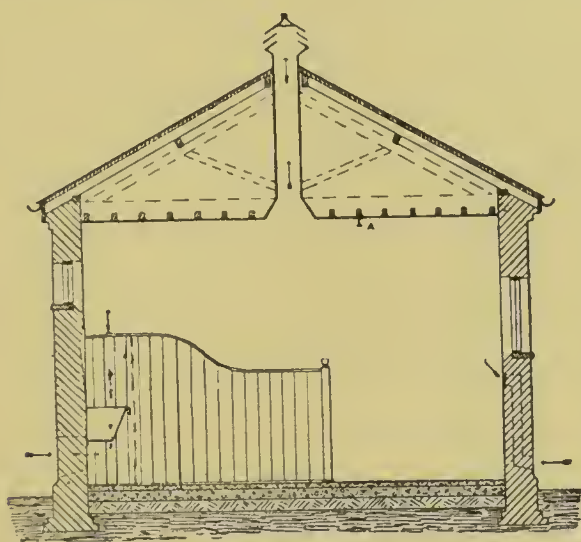


FIG. 37.

on either side, if necessary, but not on both sides at once. Fig. 38 is a section showing the method of ventilation adopted for a single row of stalls. Fresh-air inlets are provided at the eaves level of the building in the form of a continuous course of ventilating bricks, 3 in. deep, to both front and back wall, as shown at A A of sketch. In addition to the high-level fresh-air inlets mentioned, a 9 in. by 6 in. low-level fresh-air inlet, with traverse or drop opening (as indicated at B), is arranged at the head of each stall partition under the mangers, the air being allowed to circulate in the

stalls through the gratings with which each stall division is furnished. A corresponding fresh-air inlet is fixed in the front wall at the rear of each stall, or else a continuous low-level ventilating course is provided in the front wall, as indicated at C. The low-level fresh-air inlets at the head of the stall partitions under the mangers should be placed about 2 feet 6 inches above the ground outside. They assist materially in supplying fresh air direct to each horse, besides helping in the more thorough renewal of the internal air,

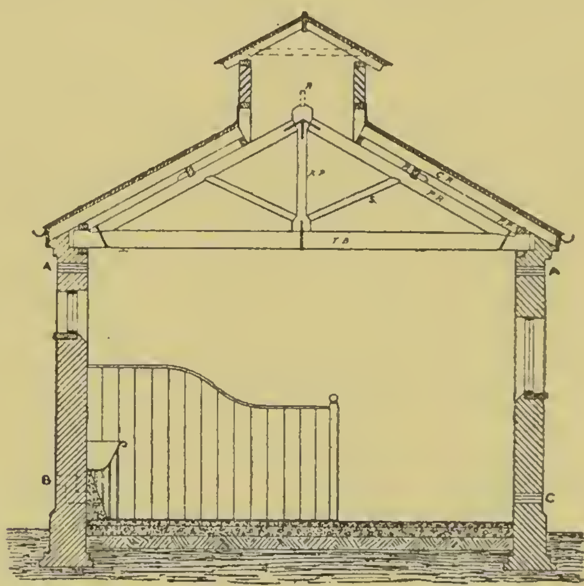


FIG. 38.

whilst the velocity of the incoming air at the low level is so greatly reduced in passing the traverse that any serious risk of horses experiencing a hurtful draught from such inlets is avoided.

In the case of stables with a double row of stalls, a slight modification of the foregoing method of ventilation is adopted, as shown in Fig. 26. Provision is made for the removal of the foul air by means of continuous ridge ventilation. The fresh air is admitted through a ventilating eaves course, as already described, and a low-level fresh-air inlet with

traverse is fixed at the head of each stall division. This provides a total effective fresh-air inlet area of about 130 square inches per horse.

Such a form of ventilation is eminently suitable for large stables where horses of robust physique are housed, and where an entire absence of complicated and expensive ventilating appliances is a necessity.

It must be remembered that, whilst providing ample ventilation by means of fresh-air inlets and foul-air outlets, all stable windows should be made to open, so that the whole building may be thoroughly flushed with large volumes of air when required.

CHAPTER VII.

TEMPERATURE AND HUMIDITY.

Temperature and Humidity :—A warm and dry atmosphere desirable—Range of temperature for stables—Warm and ill-ventilated buildings injurious to health—Artificial heating—Hot-water pipes and coils—Slow-combustion ventilating stoves—Dry air not suitable for breathing purposes—Wet and dry bulb thermometers—Definition of "dew-point"—Formula for ascertaining the dew-point—Glaisher's Factors—Formula for ascertaining the relative humidity of air—Table showing weight of vapour in air at the temperature of dew-point—An example—Percentage of humidity necessary for health—Coach-houses to be free from damp.

In connection with the adequate ventilation of stables, it is necessary to bear in mind that, as far as practicable, a fairly warm and equable temperature should be maintained within the building. Horses can only be brought to the highest physical condition in a warm and comparatively dry atmosphere. In the case of valuable animals, such as race-horses, &c., where it is essential to exercise the utmost care in every detail, it is desirable to arrange means for controlling the temperature and humidity of the internal air. During the summer time the temperature should not exceed 70° Fahr., whilst in winter it should not be allowed to fall below 45° or 50° Fahr. The most comfortable average temperature for stables may be taken at from 55° to 60° Fahr. This degree of heat should not, however, be obtained by restricting the fresh-air supply to the building, and so allowing the temperature within to be raised by retaining the warm vitiated air exhaled from the horses' lungs, together with the heat given off from the bodies of the animals.

The fact that horses thrive better in a warm rather than in a cold stable, and also that a smooth, glossy coat is more easily attained under such conditions is well known to grooms. The stableman will, therefore, frequently close all the inlet and outlct ventilators so as to produce a feeling of warmth, perfectly oblivious of the greater evils which are produced by the animals being compelled to breathe impure air again and again until it becomes completely laden with unwholesome organic matters.

Where considered necessary (as is sometimes the case in racing establishments, &c.), any artificial warming of the stables should be effected by means of stoves or heating apparatus specially designed for the purpose. In many instances they may be conveniently warmed by the provision of a series of hot-water coils connected with a boiler heated by the harness-room grate or stove. For an extensive range of buildings it would be necessary to arrange a separate heating chamber and boiler for this purpose.

Fig. 39 shows a typical arrangement of boiler and hot-water pipes for heating the coils. The flow and return pipcs should preferably be carried under the floor, so as to be out of the way of the horses. They must be covered with some good non-conducting material, such as hair-felt or slag wool. The hot-water coils should be placcd in convenient positions and protected from injury by enclosing them with ornamental gratings or coil-cases, as shown at B (Fig. 39).

Fig. 40 is an illustration of a ventilating coil made by Messrs. Rosser and Russell, which is so designed and arranged that the incoming cold frcsh air is well warmed before being distributed through the interior of the building.

Stables may also be warmed by means of one or more slow-combustion ventilating stoves placed in suitable situations, so that the cold fresh air, before being delivered into the building, is first warmed by passing through the warm air chamber of the stoves. A water pan having a constant supply of water should be fixed near each stove in order to maintain

the air at a proper standard of humidity, otherwise the air is liable to become too dry.

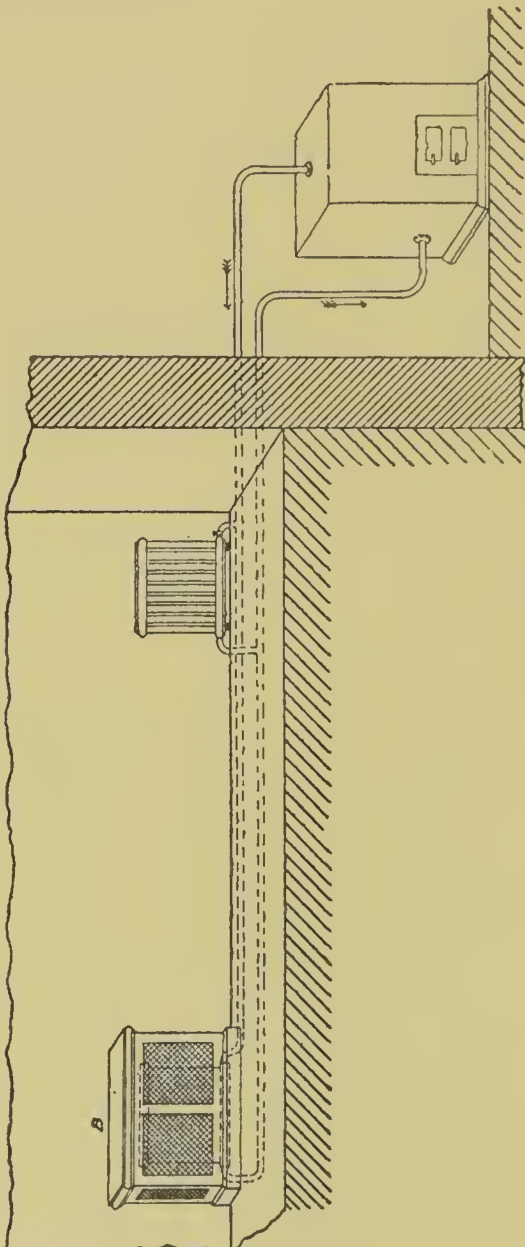


Fig. 39.

Although the air of stables must be comparatively warm and dry, yet a certain amount of humidity in the atmosphere is a necessity, for a perfectly dry air is totally unsuited for

supporting life. On the other hand, large quantities of watery vapour are given off during the process of respiration, so that if the ventilation is defective, the air within the building becomes both warm and damp. Air saturated with watery vapour is lighter than dry air at the same temperature, and for this

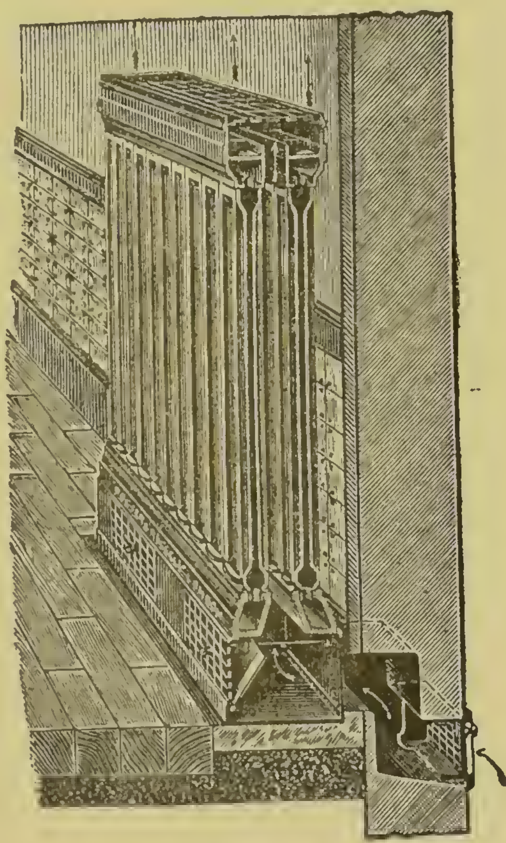


FIG. 40.

reason the moist warm air respired from the lungs readily ascends, so that proper ventilation assists in removing the excess of moisture thus given off.

The amount of moisture present in air is usually ascertained from the difference of the readings of a wet and dry bulb thermometer. This form of hygrometer consists of two delicate thermometers placed side by side. One of the bulbs is covered with muslin and kept constantly moist by being

connected with a few cotton threads to a small vessel of water. The water then rises from the vessel by capillary attraction, and the moisture is evaporated from the surface of the wet bulb with more or less rapidity, according to the dryness or dampness of the surrounding atmosphere. Heat is absorbed during the process of evaporation, and the wet bulb consequently reads lower than the dry. The greater the dryness of the air, the greater is the difference between the readings of the two thermometers. When they both record the same temperature, the air is saturated with moisture.

For purposes of comparison the humidity of the air is expressed as a percentage of the amount of vapour required to cause saturation. Perfectly dry air is represented as zero, or 0, and complete saturation as 100. To ascertain the relative humidity by means of the wet-bulb hygrometer it is necessary to first determine what is known as the "dew-point." The dew-point is found by calculating the temperature at which the amount of vapour actually present in the air would cause saturation—that is to say, the point at which the saturated air would commence to deposit dew. The "dew-point" may be ascertained by the following formula, viz.:—

$$\text{Dew-point} = T_d - F\,(T_d - T_w),$$

Where—

T_d = Dry-bulb temperature.
T_w = Wet-bulb temperature.
F = Factor for dry-bulb temperature as found in Glaisher's tables.

The following list of Glaisher's factors (page 64) will generally prove to be sufficient for ordinary purposes.

Having by this means found the temperature of the dew-point, the relative humidity of the air is ascertained as follows, viz.:—

$$\text{Humidity} = \frac{W}{W_1} \times 100.$$

Where—

W = Weight of vapour at dew-point per cubic foot of air.

W_1 = Weight of vapour per cubic foot of air neccssary to cause saturation at the actual temperature of thc air.

The subjoined table (page 65) shows the weight of vapour contained in a cubic foot of air at the temperature of dew-point—i.e. the weight of vapour necessary to cause saturation.

The following example is given in order to show the method of determining the relative humidity of the air. It is assumed that the dry and wet bulbs of the hygrometer read 64° and 58° Fahr. respectively; there is consequently a difference of 6° Fahr. between the two readings. From the formula—

$$\text{Dew-point} = T_d - F\,(T_d - T_w)$$

We have—

$$\begin{aligned}\text{Dew-point} &= 64 - 1{\cdot}83\,(64 - 58)\\ &= 64 - 10{\cdot}98\\ &= 53{\cdot}02^\circ \text{ Fahr.}\end{aligned}$$

By the application of table B, it is found that the weight of vapour at the dew-point of 53·02° Fahr. lies somewhere between 4·55 and 4·71 grains per cubic foot, or as nearly as possible about 4·55 grains; whilst the weight of vapour required to produce saturation at a temperature of 64° Fahr. is 6·59 grains. Therefore from the formula—

$$\text{Humidity} = \frac{W}{W_1} \times 100$$

We have—

$$\begin{aligned}\text{Humidity} &= \frac{4{\cdot}55}{6{\cdot}59} \times 100\\ &= 69 \text{ per cent of saturation.}\end{aligned}$$

TABLE A (Glaisher's Factors).

Table of Factors for Computing the Temperature of the Dew-Point by Means of a Wet-Bulb Hygrometer.

Dry-Bulb Temperature.	Factor.	Dry-Bulb Temperature.	Factor.	Dry-Bulb Temperature.	Factor.
Degrees Fahr.		Degrees Fahr.		Degrees Fahr.	
20°	8·14	44°	2·18	68°	1·79
21°	7·88	45°	2·16	69°	1·78
22°	7·60	46°	2·14	70°	1·77
23°	7·28	47°	2·12	71°	1·76
24°	6·92	48°	2·10	72°	1·75
25°	6·53	49°	2·08	73°	1·74
26°	6·08	50°	2·06	74°	1·73
27°	5·61	51°	2·04	75°	1·72
28°	5·12	52°	2·02	76°	1·71
29°	4·63	53°	2·00	77°	1·70
30°	4·15	54°	1·98	78°	1·69
31°	3·70	55°	1·96	79°	1·69
32°	3·32	56°	1·94	80°	1·68
33°	3·01	57°	1·92	81°	1·68
34°	2·77	58°	1·90	82°	1·67
35°	2·60	59°	1·89	83°	1·67
36°	2·50	60°	1·88	84°	1·66
37°	2·42	61°	1·87	85°	1·65
38°	2·36	62°	1·86	86°	1·65
39°	2·32	63°	1·85	87°	1·64
40°	2·29	64°	1·83	88°	1·64
41°	2·26	65°	1·82	89°	1·63
42°	2·23	66°	1·81	90°	1·63
43°	2·20	67°	1·80		

TABLE B.

TABLE SHOWING WEIGHT OF VAPOUR CONTAINED IN A CUBIC FOOT OF AIR AT THE TEMPERATURE OF DEW-POINT, THE BAROMETRIC PRESSURE BEING 30 INCHES.

Temperature of Dew-Point.	Weight of Vapour per Cubic Foot of Air.	Temperature of Dew-Point.	Weight of Vapour per Cubic Foot of Air.	Temperature of Dew-Point.	Weight of Vapour per Cubic Foot of Air.
Degrees Fahr.	Grains.	Degrees Fahr.	Grains.	Degrees Fahr.	Grains.
20°	1·30	44°	3·32	68°	7·51
21°	1·36	45°	3·44	69°	7·76
22°	1·42	46°	3·56	70°	8·01
23°	1·48	47°	3·69	71°	8·27
24°	1·54	48°	3·82	72°	8·54
25°	1·61	49°	3·96	73°	8·82
26°	1·68	50°	4·10	74°	9·10
27°	1·75	51°	4·24	75°	9·39
28°	1·82	52°	4·39	76°	9·69
29°	1·89	53°	4·55	77°	9·99
30°	1·97	54°	4·71	78°	10·31
31°	2·05	55°	4·87	79°	10·64
32°	2·13	56°	5·04	80°	10·98
33°	2·21	57°	5·21	81°	11·32
34°	2·30	58°	5·39	82°	11·67
35°	2·39	59°	5·58	83°	12·03
36°	2·48	60°	5·77	84°	12·40
37°	2·57	61°	5·97	85°	12·78
38°	2·66	62°	6·17	86°	13·17
39°	2·76	63°	6·38	87°	13·57
40°	2·86	64°	6·59	88°	13·98
41°	2·97	65°	6·81	89°	14·41
42°	3·08	66°	7·04	90°	14·85
43°	3·20	67°	7·27		

Where practicable, the dry-bulb thermometer should read from 60° to 65° Fahr., and the wet-bulb from 55° to 60° Fahr. The difference between the two thermometers should not be less than 4° or more than 8° Fahr. Generally, it may be stated that for health and comfort a humidity of 70 per cent. should be approximately maintained.

With reference to coach-houses attached to first-class stables, arrangements are frequently made whereby the interior of these buildings may be kept warm and dry with hot-water circulating pipes fixed round the walls. By this means all the carriages and their upholstery are maintained in a good and serviceable condition.

CHAPTER VIII.

GENERAL PLAN.

General Plan:—Average dimensions of stables—Stall divisions—Loose boxes—Infirmary stables—Infirmary loose boxes—Stables arranged with feeding passage—Two-story stables—Fire-brigade stables—Horse bath—Smithy—Forage stores—Miscellaneous memoranda—Arrangement of cow-houses.

Stables designed for a single row of stalls should have a width of about 18 feet, the stall divisions being about 11 feet long over all, with a passage in rear about 7 feet wide. In the case of stables arranged with a double row of stalls the central passage should be 9 feet wide, making a total width of 31 feet. Frequently, however, the stall divisions are only 9 feet 6 inches or 10 feet long, with a 6-feet passage for a single row of stalls, and a central passage 8 feet wide where a double row of stalls is provided; but for first-class stables this is insufficient.

For ordinary purposes the stalls should not be less than 6 feet wide; but for hunting-stables and others of a similar description it is desirable to make them 6 feet 6 inches or 7 feet wide. Loose boxes should be double the width of a stall, 12 feet being the usual width, whilst the length should not be less than 12 feet. Preferably, loose boxes should be 12 feet wide and 14 feet long.

Infirmary stables should be about 20 feet wide, the stalls being 11 feet long by 6 feet 6 inches wide, with a 9-feet passage in rear. Infirmary loose boxes should be not less than 16 feet long by 13 feet wide, so as to provide ample floor area and air space.

Fig. 41 is the plan of a stable with a double row of stalls and central passage, having accommodation for 14

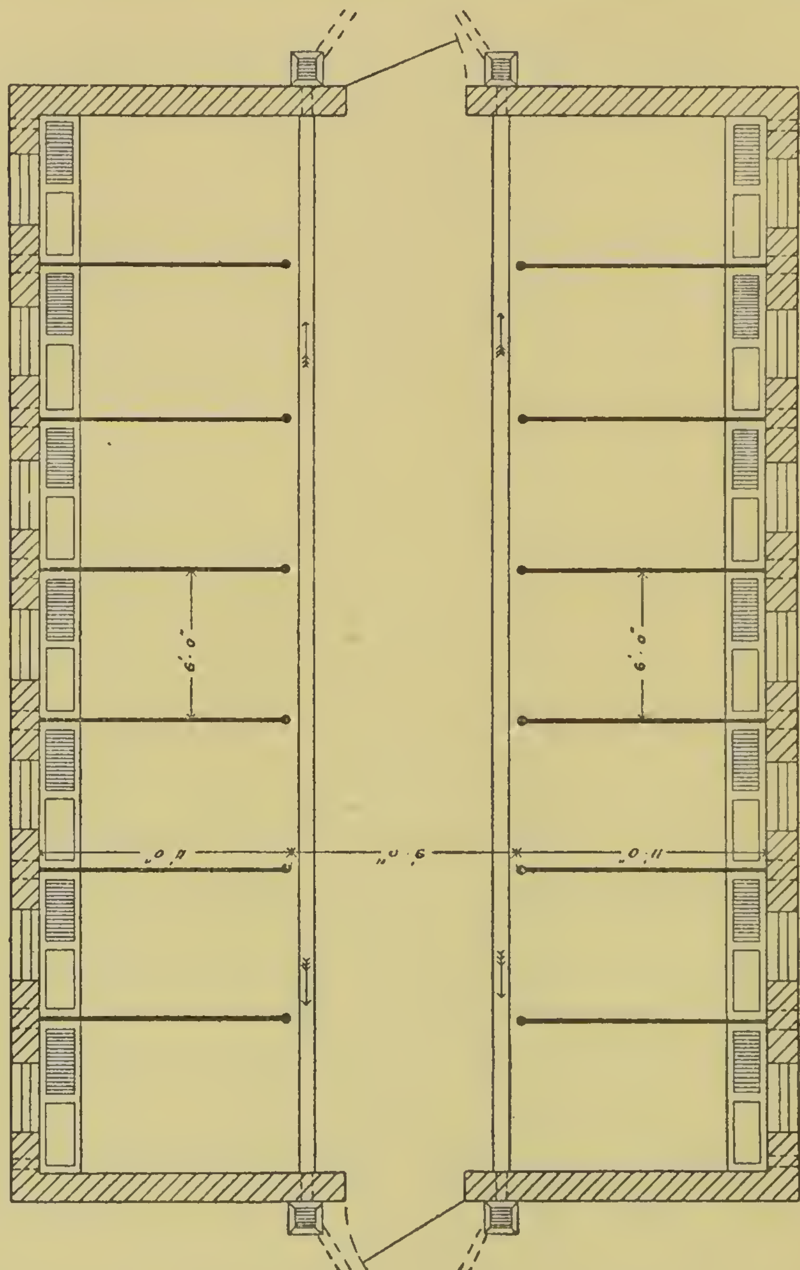


Fig. 41.

horses. Fig. 42 shows the plan of a stable with a single row of stalls and two loose boxes, with passage at rear. Occasionally a feeding passage, about 3 feet 6 inches wide,

is provided at the head of the stalls, as in Figs. 43 and 44, where stables are shown arranged with a single and double

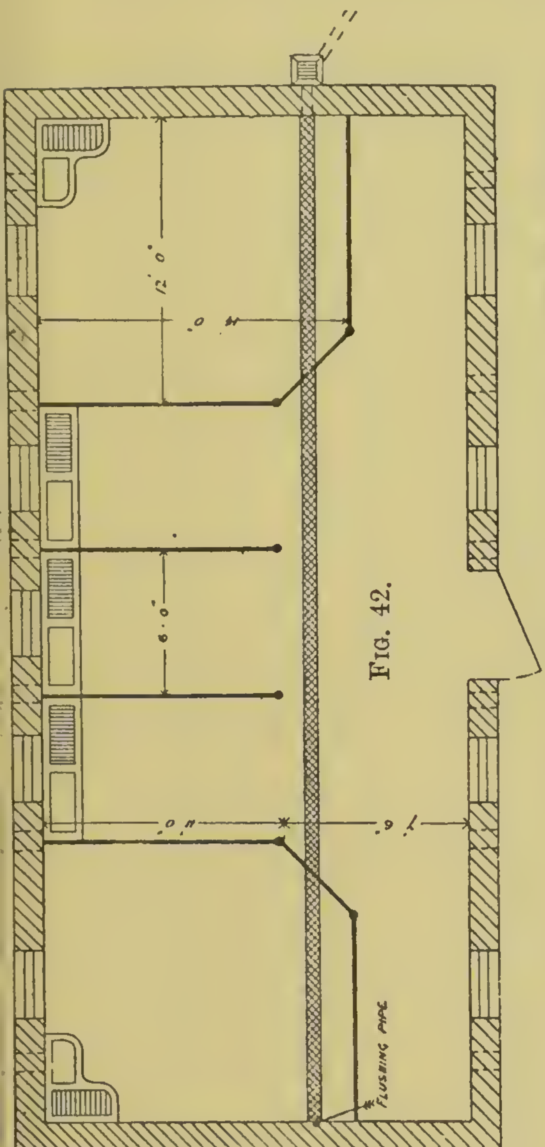


FIG. 42.

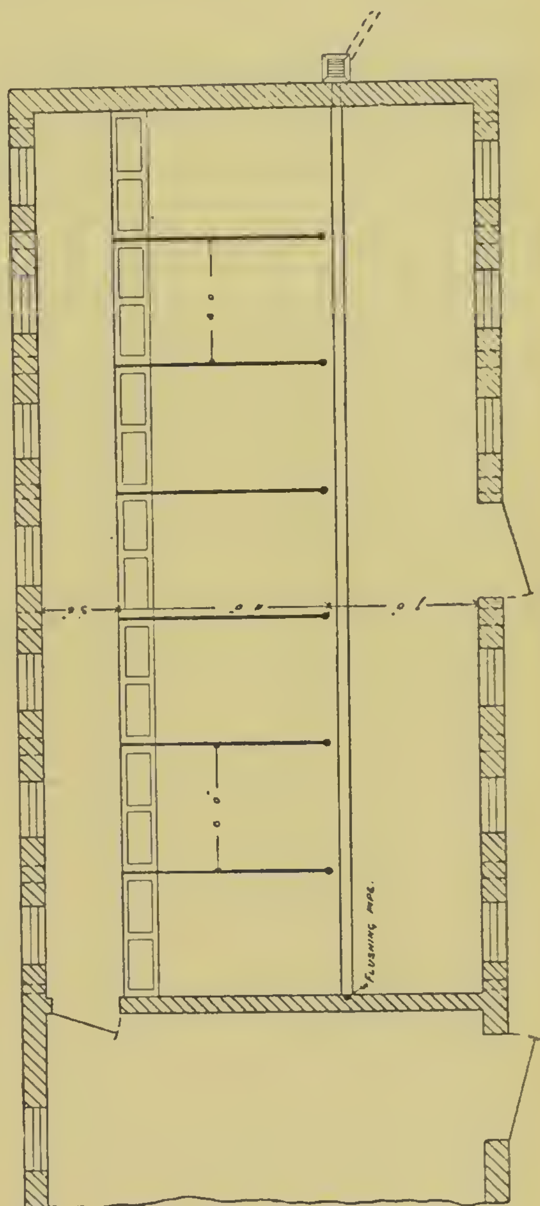


FIG. 43.

row of stalls respectively; but for general purposes the feeding passage is unnecessary. Fig. 45 is the plan of a range of four loose boxes, such as are largely used in hunting

establishments, whilst Fig. 46 shows the plan for a block of three infirmary loose boxes.

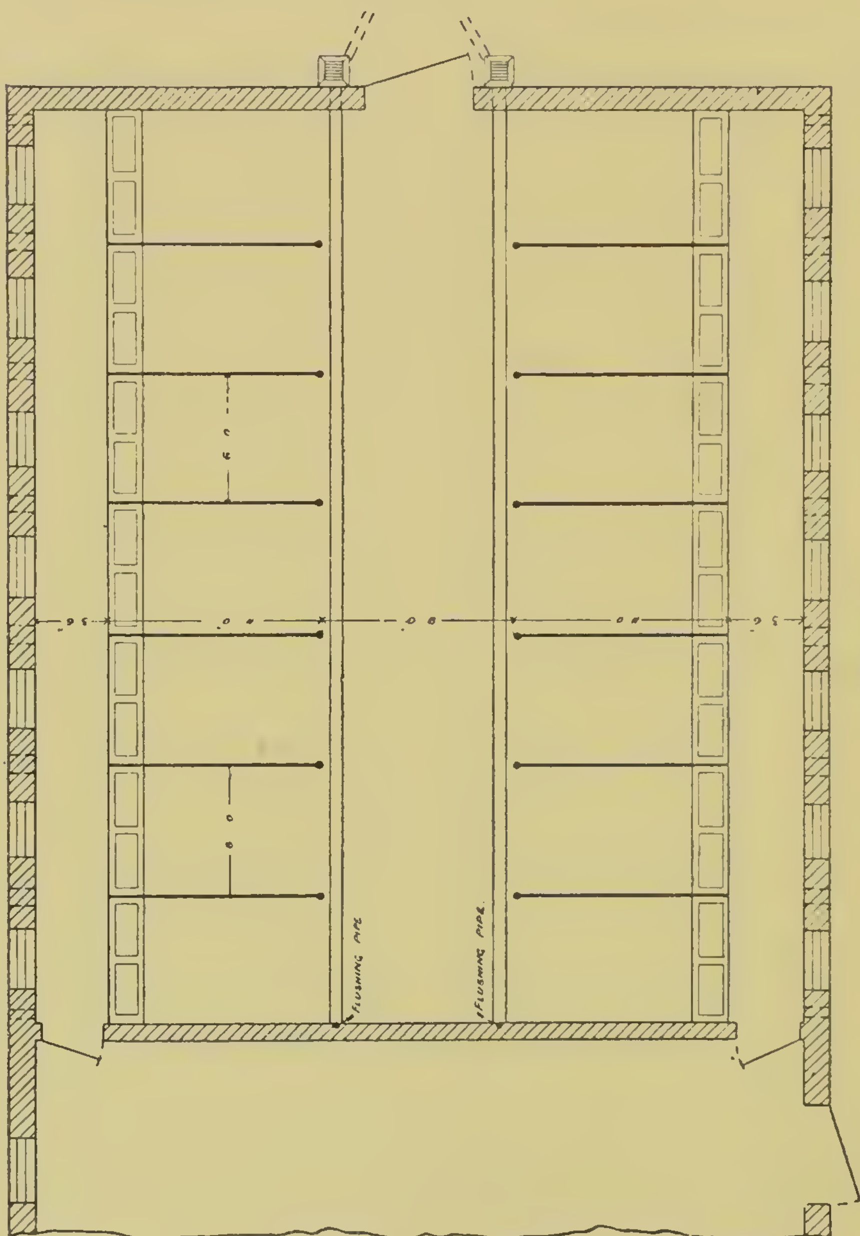


FIG. 44.

In thickly populated towns and cities, where space is limited, and accommodation must be provided for a large number of horses and vehicles, the ground floor is often

arranged so as to afford shelter for waggons, carts, &c.; whilst the necessary stable accommodation is provided on

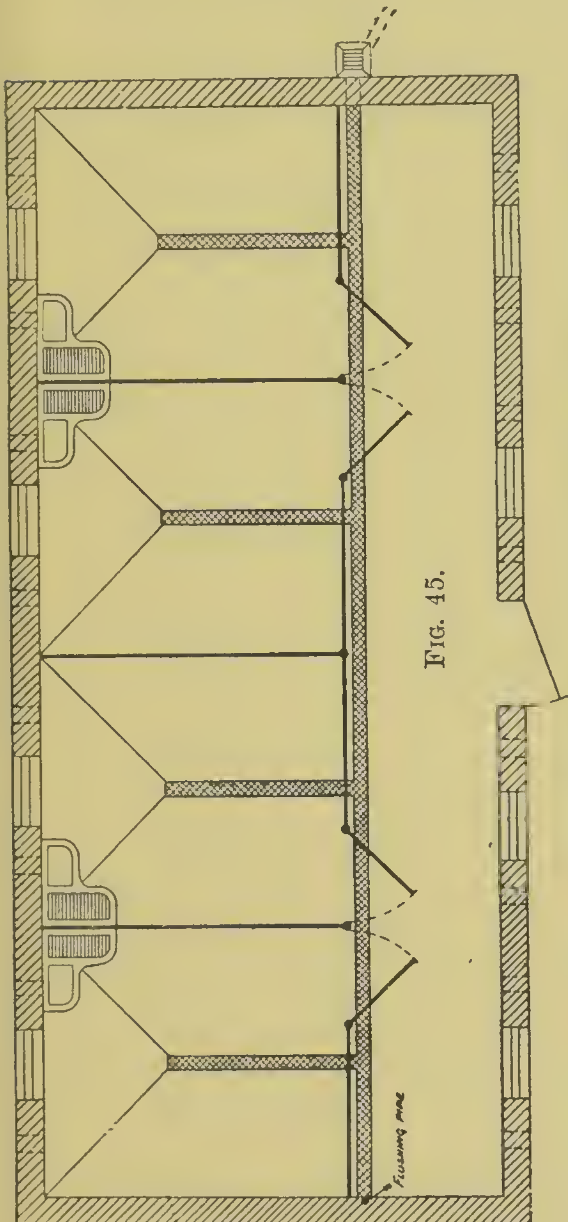


Fig. 45.

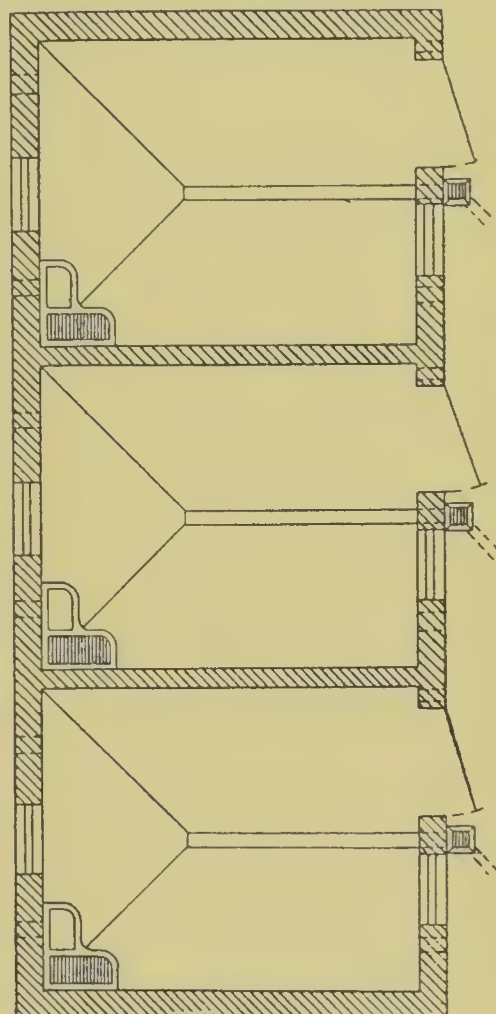


Fig. 46.

the first floor of the building, the stables being reached by means of an inclined plane of sufficiently easy gradient to be readily ascended by horses. For tramway and omnibus

companies two-story stables have been erected, in which both the ground and first floor are occupied as stables.

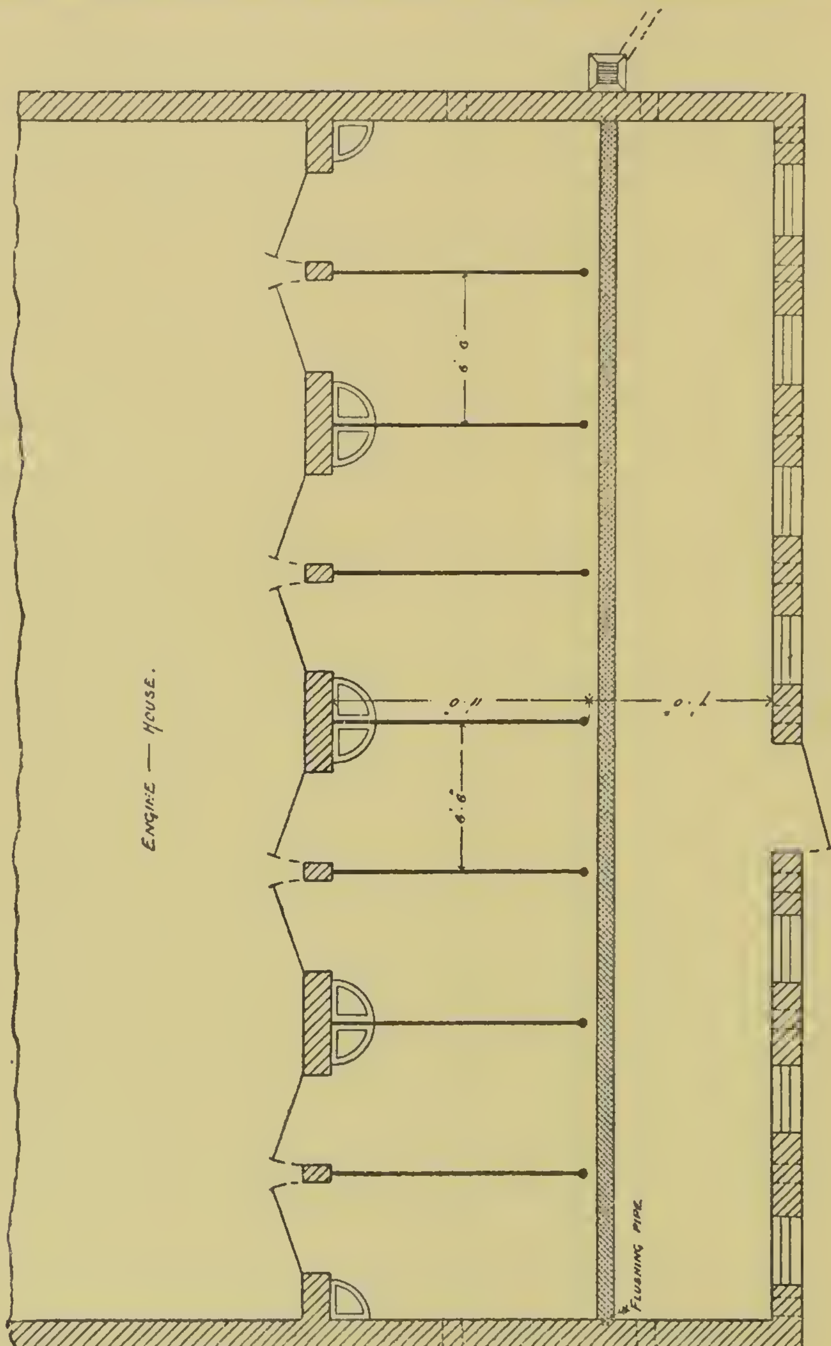


FIG. 47.

Fig. 47 shows a general arrangement of stalls suitable for the stables of a fire-brigade station, which has been adopted

with satisfactory results. It will be noticed that a door is placed at the head of each stall, which opens directly into the engine-house, so that the horses may be attached to the engines without loss of time. In carrying out this design, it is necessary to use some form of angle manger with overhead hay-rack, whilst the angles of the door jambs should be well rounded, or a metal roller fixed vertically at each angle, so that the horses may not be injured in the hurry of a fire alarm.

For establishments where many horses are kept, it is desirable that one or more of the sick boxes should be provided with a set of stout hooks and belaying pins, so that an injured horse may be readily slung when necessary. A hot and cold horse bath is also a very useful adjunct to the infirmary boxes. It should be capable of being supplied with water heated to about 160° Fahr. if required, so that in an emergency it may be used as a steam bath for veterinary purposes.

A forge and shoeing shed is generally provided in connection with stabling intended to accommodate a large number of horses. The former building is equipped with bellows, anvils, water troughs, bench, vices, &c., according to the requirements of each particular case. Both the smithy and shoeing shed require to be well lighted and ventilated.

The forage stores should be kept quite distinct from the stables, care at the same time being taken that they are perfectly dry and well ventilated. Where the stores are placed over the stables, they should be separated by a thoroughly impervious floor, so that the fodder may not in any way be contaminated by the emanations from below. For convenience in calculating the size of store rooms necessary to contain a given quantity of forage, &c., the following miscellaneous memoranda will be found useful:—

A load of hay = 36 trusses = 18 cwt.
A load of straw = 36 trusses = $11\frac{1}{4}$ cwt.
A truss of hay = 56 lb. = 10 cubic feet approximately.

A truss of straw = 36 lb. = 10 cubic feet approximately.

A cubic yard of hay compressed for shipping = 270 to 300 lb.

A bushel of oats (new) should weigh not less than 38 lb.

A bushel of oats (old) should weigh not less than 42 lb.

A bushel of beans should weigh not less than 62 lb.

A bushel of barley should weigh not less than 50 lb.

A bushel of maize should weigh not less than 60 lb.

A bushel of oatmeal should weigh not less than 47 lb.

A bushel of peas should weigh not less than 62 lb.

A bushel of wheat should weigh not less than 60 lb.

A cubic yard = 21 bushels.

A bushel = 1·284 cubic feet.

8 bushels = 1 quarter = $10\frac{1}{4}$ cubic feet.

Cow-houses, for a single row of stalls with feeding passage, should have a total width of about 18 feet, as shown in Fig. 48. This allows a feeding passage 3 feet

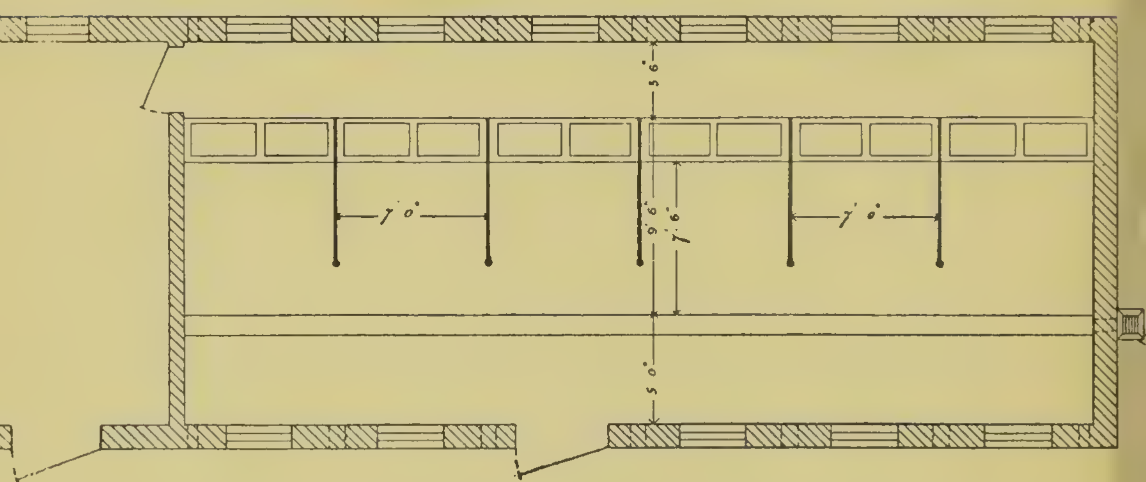


FIG. 48.

6 inches wide, feeding trough 2 feet wide, with stalls or "standings" 7 feet 6 inches long, and a 5-feet passage (including gutter) at rear. In the case of cattle it is usual to house them in pairs, so that a stall division is provided

between every two cows. The width of a double stall should therefore not be less than 7 feet, in order that a minimum breadth of 3 feet 6 inches may be allowed for

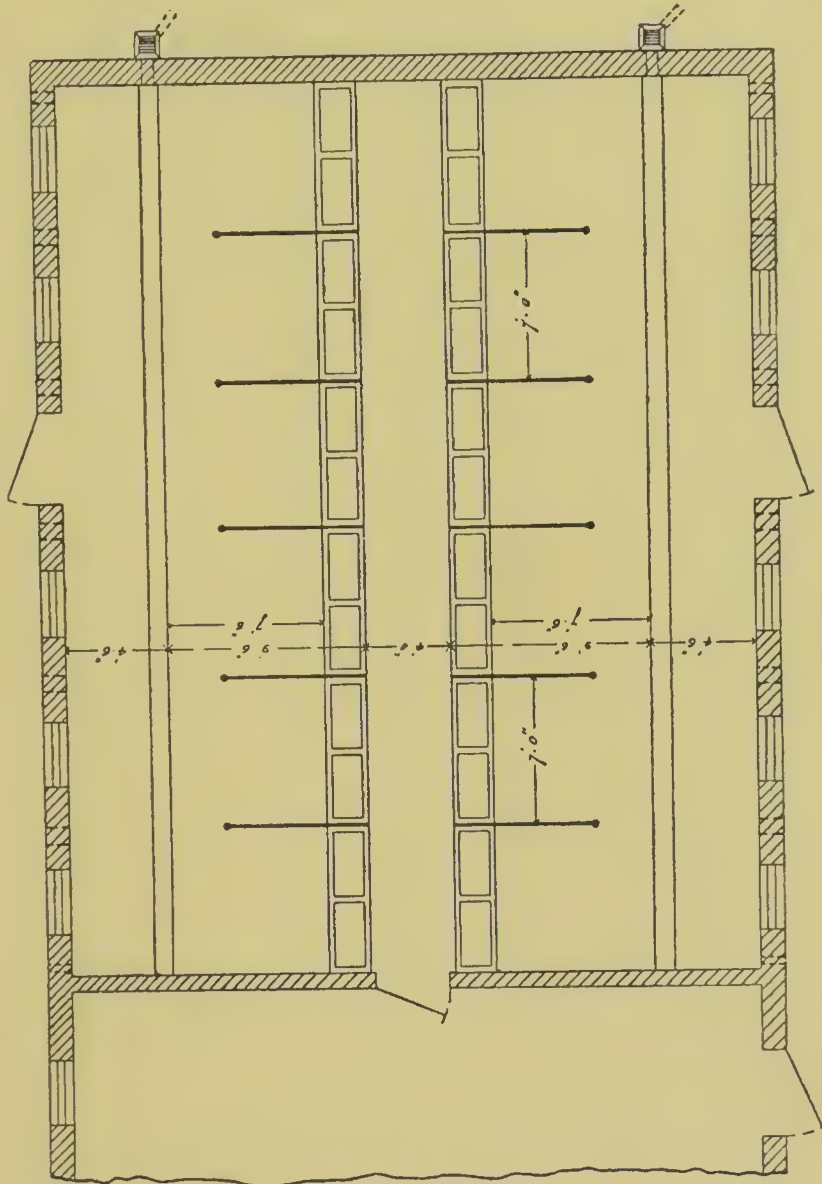


FIG. 49.

each animal. Where circumstances permit, especially when it is intended to accommodate stock of large size, it is better to make the stalls 7 fect 6 inches or 8 feet widc. Occasion-

ally cow-houses are arranged with separate stalls for each cow, and for this purpose they should be not less than 4 feet 6 inches wide. Where this method is adopted a few

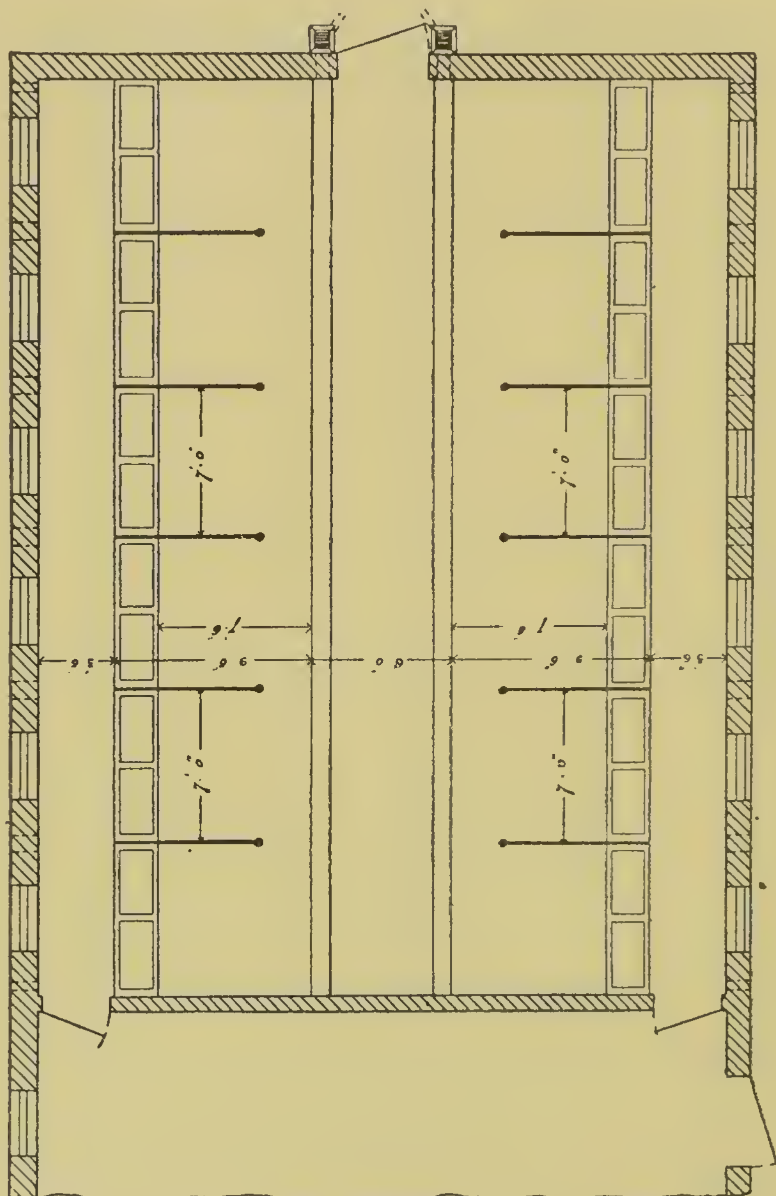


Fig. 50.

double cow-stalls should be provided for use in calving time, unless loose boxes are available.

The most satisfactory arrangement for a large cow-house

consists of a building designed with a double row of stalls, as in Fig. 49. This gives a central feeding passage 4 feet wide,

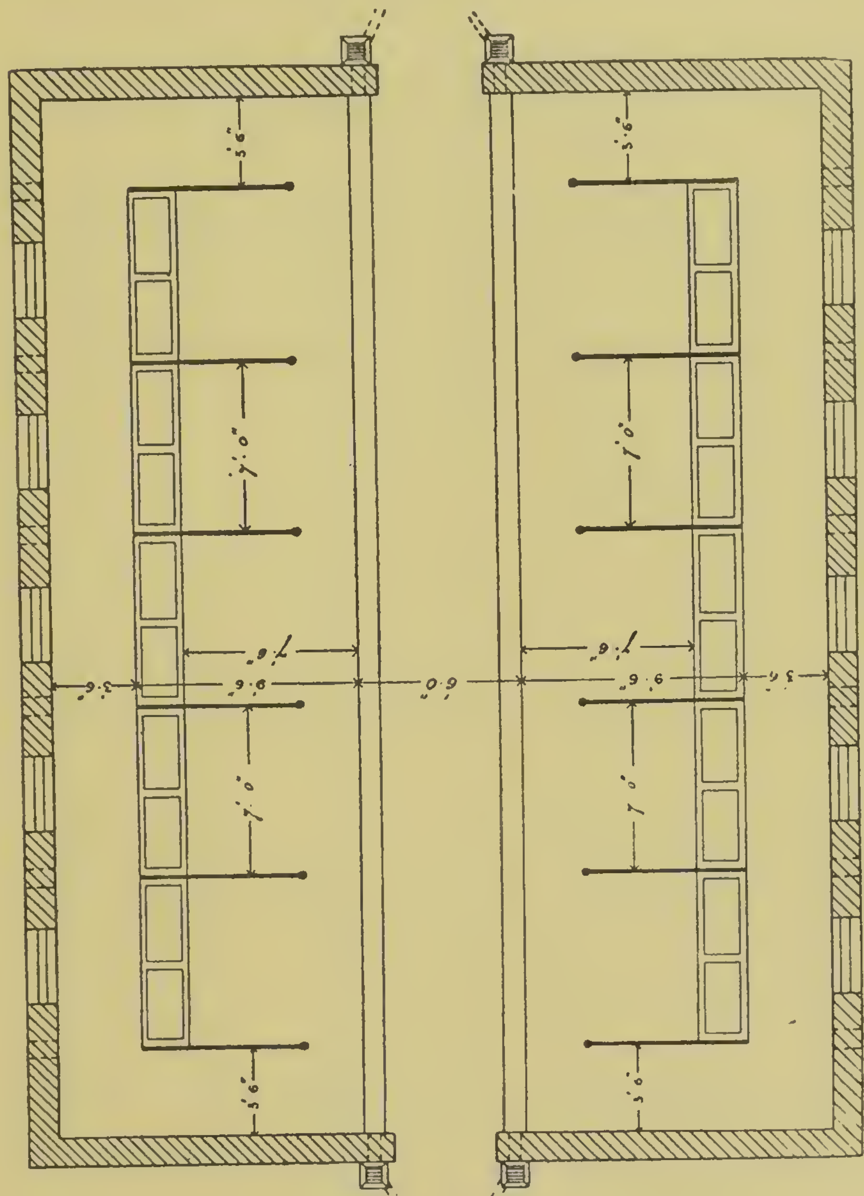


FIG. 51.

two rows of stalls 9 feet 6 inches long (including mangers), with a 4-feet 6-inch passage at the rear of each, making a total width of 32 feet.

For convenience of serving, a light tramway is frequently laid throughout the length of the feeding passage, having direct communication with the forage and root stores.

Fig. 50 is the plan of another arrangement, for a double cow-house with a separate feeding passage for each row of stalls. The total width is 32 feet, and is made up of a central passage 6 feet wide, two rows of stalls 9 feet 6 inches long, with a 3-feet 6-inch feeding passage to each. Of the two plans, that shown in Fig. 49 is the most convenient.

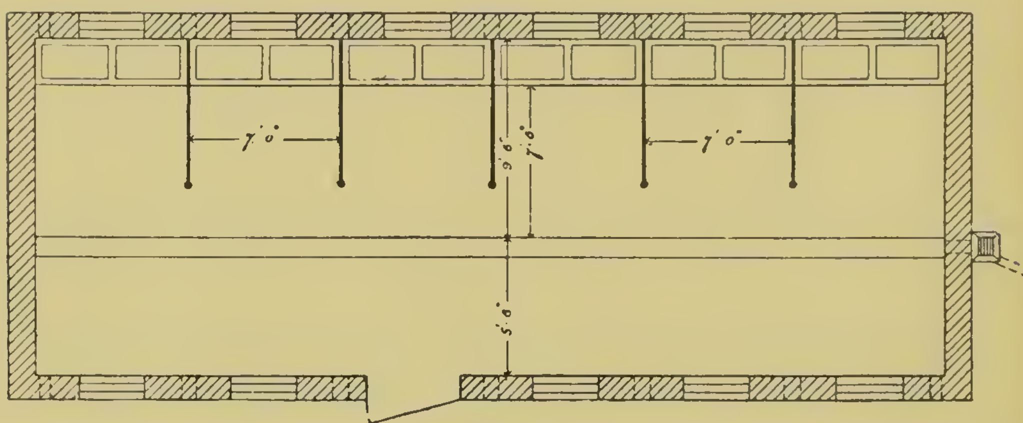


Fig. 52.

Fig. 51 is similar in general construction to that shown in Fig. 50, except that the feeding passages are entered from the ends of each row of stalls, instead of separate entrances being provided from the root or other store attached to the cow-house.

Where economy is the first consideration, the feeding passage is sometimes omitted, as in Fig. 52. Cow-houses of this type are, however, very inconvenient, owing to the difficulty experienced in properly feeding and serving the cattle when the stalls are fully occupied.

CHAPTER IX.

WATER SUPPLY.

WATER SUPPLY :—To be free from impurities—Rain water preferred for drinking purposes—Classification of waters—Definition of "hard" water—Temporary hardness—Permanent hardness—Softening waters by boiling—Clark's soap test—Injurious effects of hard water—Clark's softening process—The Porter-Clark method—Quantity of water required per horse—Rain-water tanks—Manger basins.

WHILST it is essential that an ample supply of water should be available at all times for various purposes, it is also necessary to remember that the character of the water supplied for drinking will exercise an important influence on the health of the animals for whom it is provided. It need scarcely be stated that all drinking water should be perfectly free from any contamination with sewage and other foul matters; for not only is the health of the animals themselves endangered, but in the case of cattle supplied with impure water, many serious diseases may be directly transmitted to human beings through the medium of the milk.

Where the choice of drinking water is left to the animals themselves, it will be found that they invariably choose the soft waters of rivers or lakes in preference to the hard waters of deep wells, &c. For potable purposes, the most wholesome water, either for men or animals, is pure rain water; but, unfortunately, in practice, rain-water is too often rendered impure by contamination with dirty collecting surfaces, or by being allowed to stagnate in ill-ventilated and neglected tanks containing a large amount of sediment and dirt. Owing to the waters from rivers and small lakes being liable to be fouled with sewage and other impurities, as a rule it is generally advisable to rely upon deep-well water, or water supplied from a local water company, for drinking purposes.

The classification of waters derived from various sources, according to their relative fitness for drinking, as given by the Rivers Pollution Commissioners, is shown in the following table, viz. :—

TABLE SHOWING RELATIVE FITNESS OF VARIOUS WATERS FOR DRINKING PURPOSES.

No.	Source.	Fitness for Drinking.	Palatability.
1	Spring water	Wholesome	Very palatable
2	Deep-well water	Ditto	Ditto
3	Upland surface water ..	Ditto	Moderately palatable
4	Stored rain water	Suspicious	Ditto
5	Surface water from cultivated land	Ditto	Palatable
6	River water to which sewage water gains access ..	Dangerous	Ditto
7	Shallow-well water	Ditto	Ditto

The arrangement of these waters in the order of their softness is as follows :—

TABLE SHOWING RELATIVE SOFTNESS OF VARIOUS WATERS.

No.	Source.	Degree of Softness.
1	Stored rain water	Very soft
2	Upland surface water	Soft
3	Surface water from cultivated land	Ditto
4	River water	Hard
5	Spring water	Very hard
6	Deep-well water	Ditto
7	Shallow-well water	Ditto

Water is called hard when it holds in solution a certain proportion of salts of lime or magnesia; those most commonly met with are salts of lime, such as carbonate of lime and sulphate of lime. Carbonate of lime is almost insoluble in pure water, but it easily dissolves in water containing carbonic acid.

The comparative hardness of water is measured by the number of grains of dissolved saline matters present in a gallon of water (1 gallon = 70,000 grains) each grain being called a "degree." For instance, water containing 12 grains of chalk per gallon is said to have 12° of hardness. Waters which do not exceed 5° of hardness may, for ordinary purposes, be considered as soft, and when exceeding 12° as hard. The following gives the average degree of hardness of certain descriptions of waters:—

Upland surface water	5°
River water	12°
Spring water	26°

Where the hardness of the water is produced by carbonate of lime held in solution, it is known as a "temporarily-hard water," for the greater portion of the chalk may be removed by boiling, and the water thus rendered comparatively soft. When such water is boiled, a large part of the carbonic acid is driven off and the excess of carbonate of lime is deposited on the sides and bottom of the vessel. The incrustations of carbonate of lime or chalk which occur in kettles and boilers are matters of everyday observation, and are illustrative of the process of softening a "temporarily-hard water." On the other hand, if the hardness of the water is due to dissolved sulphate of lime, then such waters are called "permanently hard," for no amount of boiling will soften them.

The degree of hardness of water is ascertained by means of Clark's soap test. Advantage is taken of the fact that soap on being dissolved in pure water immediately forms a

lather, but when mixed with a hard water (i.e. water containing salts of lime or magnesia), no lather is obtained until these minerals have been precipitated, the oil or fat in the soap combining with the lime or magnesia to form insoluble compounds which are seen floating in the water in the shape of multitudinous, light, flaky particles. If sufficient soap is added the whole of the lime and magnesia is eventually thrown down.

Clark's standard soap solution consists of soap dissolved in alcohol. The quantity of soap in the solution is accurately known, and a definite amount of the solution is gradually added to a measured quantity of the water to be tested. When these are well shaken together no permanent froth or lather will be produced until the whole of the lime and magnesia has been precipitated. From a calculation of the quantity of standard soap solution used in order to produce a permanent froth or lather, the quantity of lime and magnesia contained in the water—and consequently the degree of hardness—is ascertained.

Some stablemen will occasionally go through the operation of partially washing their hands in a bucket of water (although their hands may be quite clean), and after removing the scum which has formed on the surface, will give the water to their horses to drink. By this means the water is slightly softened, even though the rationale of their proceedings may not always be obvious to them. It need scarcely be said that such a method of softening water for drinking purposes is not to be recommended.

Animals supplied with very hard waters for drinking purposes are liable to various intestinal disorders, whilst the harsh, dry coat of horses frequently results from the same cause. For racers, hunters, and other valuable horses, it is desirable that very hard waters should be softened, either by boiling or by subjecting the water to some other softening process. In the method introduced by Dr. Clark, this is

effected by the addition of a saturated solution of lime to the water to be softened, the excess of carbonic acid present in the water being thereby neutralised, so that a solid precipitate of chalk is obtained.

The Porter-Clark process is a modification of that just mentioned, in which several mechanical improvements have been introduced to assist in the more rapid and complete softening of the water.

A horse of average size will drink from seven to eight gallons of water per diem, whilst about three gallons will be required for washing purposes, in addition to which an allowance of five or six gallons per horse is necessary for stable cleaning, &c. Provision should, therefore, be made for a minimum daily supply of sixteen gallons per horse for drinking, washing, and stable-cleaning purposes.

Cattle require from five to six gallons of water per day. For all purposes, the total supply for cow-houses may be estimated at twelve gallons per head per day.

In districts where there is a great scarcity of water, the rain water from the roofs may be stored in a water-tight, well-ventilated, underground tank, the rain water first passing through a small settling and filter chamber. Both the settling chamber, filter chamber, and storage tank should be frequently inspected and periodically cleansed, and the whole so designed that there may not be the slightest danger of the water being polluted by sewage or other matters of this nature. A storage tank with cement concrete sides and roof, not less than 18 inches thick, well finished on the inside with cement rendering about 1 inch thick —the surface being brought to a perfectly smooth face with neat cement—will be found to provide a water-tight reservoir.

A water basin frequently forms an integral part of the manger fittings of stables, the water supply being regulated by means of a specially constructed tap, whilst the waste pipe

from the basin discharges upon the surface channel of the stall. For ordinary stables the water basin is, however, omitted, the horses being supplied with water by hand when they require it, either by taking the animals outside and watering them at stated times, or allowing them to drink in the stable from a bucket.

CHAPTER X.

LIGHT.

Light:—Its necessity—Disadvantages of ill-lighted stables—Size and position of windows—Hinged sashes—Window gratings—Skylights —Windows to be made to open—Pivoted sashes—Windows with "hit-and-miss" ventilators—Artificial light—Electricity—Gas—Oil and candles—Arrangement of stable lamps.

Abundance of light as well as air is an absolute necessity for the promotion of robust health; but in many instances little attention is paid to this matter, no attempt apparently being made to secure the adequate lighting of ordinary stables and cow-houses. In addition to the unfavourable results which the absence of light produces upon the general health, it may be observed that in some cases the temperament of the animals is directly affected when confined for any length of time in a badly lighted building, and they are apt to be rendered somewhat morose and untractable in disposition.

It is within the experience of everyone that the sudden transition from the cheerless gloom of a dark building into full daylight produces a sense of blindness and indistinctness of vision which, for the time being, is both painful and alarming, whilst the surrounding objects assume most unnatural shapes. The same effect is produced upon horses when taken from an ill-lighted stable into the glaring sunlight outside. The sudden change and the unreal appearance of everything around frightens them, so that they become nervous and suspicious. Should these traits be developed in a great degree, such horses in time become what are commonly known as "shiers" or "starters," and the danger and discom-

fort of riding or driving animals of this description need not be commented upon. All stables should therefore be well lighted; but it is essential that there should be an entire absence of glare, so that the eyesight may not in any way be affected.

Where the lighting is obtained from windows in the front and back walls of the building, it should be so arranged that the greatest amount of light enters at the rear of the horse. Stables having only a single row of stalls should be designed with a small window (having an area of about $4\frac{1}{2}$ feet superficial) at the centre of each stall, directly over the horse's head, together with a window at the rear, as shown in Fig. 37, or in some cases a large window may be placed behind every two horses. The windows at the rear of each stall should have an area of about 9 feet superficial, whilst if large windows are placed behind every pair of stalls in lieu of the arrangement shown in Fig. 37, they should be large enough to admit not less than 18 feet superficial of light. This will provide a total window area of 13 to 14 feet superficial per horse.

On sanitary grounds it is preferable that the windows be constructed of iron instead of wood, the former material being much more non-absorbent. A suitable window (size 3 feet 3 inches by 1 foot 5 inches) for placing at the head of each stall is shown in Fig. 53. The sash and frame are of iron, the sash being hinged at the bottom and readily opened and closed by means of the small slide bar B. A similar description of window (size 3 feet 3 inches by 2 feet 10 inches) for fixing at the rear of each stall is shown in Fig. 54. The upper half of the sash is made to open in the manner already described.

The windows at the head of the stalls should be placed at least 8 feet above the floor of the stable, whilst those at the rear should be 4 feet 6 inches or 5 feet above the floor level. If considered requisite, the window openings may be protected by means of wrought-iron bars built into the walls

on the outside, or by the provision of external cast-iron gratings, as shown in Fig. 55.

For stables having two rows of stalls with an open roof, the principal portion of the light may be provided by means of a skylight constructed in the roof, as shown at A in

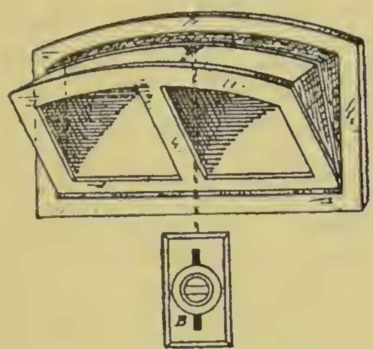


Fig. 53.

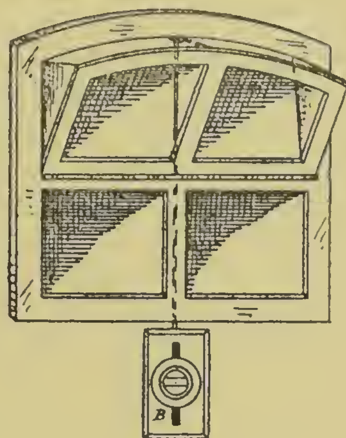


Fig. 54.

Fig. 29 : but under such circumstances care should be taken that the light is obtained from the north side of the building (or the side least exposed to the direct rays of the sun), so as to avoid any excess of heat or glare within. The top or roof

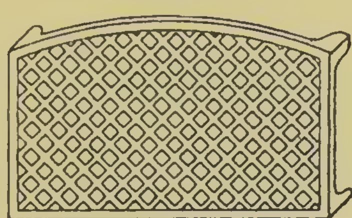


Fig. 55.

lighting should also be supplemented by means of a small window similar to that shown in Fig. 53, provided over the head of each horse at a height of 8 feet above the floor-level. Where a ceiling is provided, and the whole of the light must consequently be obtained from the side walls only, then, in

double stables, the window over each stall should have a superficial area of 8 or 9 feet.

In the case of infirmary loose boxes it is desirable to provide a total window area of not less than 16 to 18 feet superficial to each sick box, so that a sufficiency of light may be obtained.

The lighting of cow-houses should be carried out in a similar manner to that already described for stables.

All windows should be made to open, so as to provide for any additional ventilation that may be required at any time, and for thoroughly flushing the building with air when

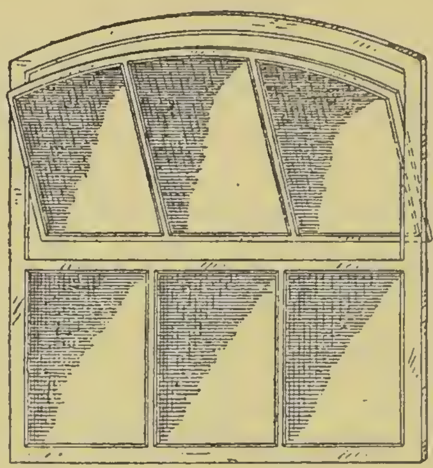


FIG. 56.

necessary. By this means a valuable auxiliary to the ordinary ventilating appliances is always available. During that portion of the day when the stables are unoccupied, it is an excellent practice to open all the doors and windows, so that the whole of the internal air may be immediately and entirely renewed by perflation—i.e. allowing the external air to blow freely through the open doors and windows of the building.

The sashes of stable windows may be hung on pivots, as shown in Fig. 56, if desired; but it is considered that the arrangement shown in Figs. 53 and 54 is preferable.

Fig. 57 shows a common form cf ventilating window frequently used in farm stables and cow-houses of cheap construction. It is provided with what is known as a "*hit-and-miss*" ventilator for the admission of air. For buildings of this description the hit-and-miss ventilating windows are usually made of wood ; but they can also be obtained in cast iron if desired.

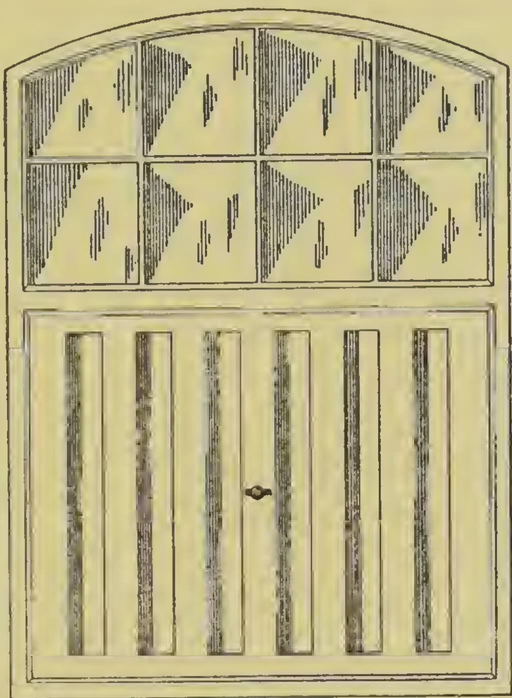


FIG. 57.

Where provision is made for lighting stables at night, every care must be taken that it is so arranged as to avoid any risk of fire occurring when in use. The safest and best artificial light that can be adopted is electricity. Such a means of lighting is available in most large towns and populous districts, whilst many country residences are now fitted with their own electrical installation. Provided that the wiring of the buildings is properly carried out, there is no danger either from fire or of injury from the electric current.

Next to the electric light, gas is preferred. The lights should be entirely enclosed with glass, and provided with external wire guards to prevent the lamps being accidentally damaged. The usual method of lighting stables with gas is by means of wall lamps or brackets. A sketch of a wall lamp as ordinarily used is shown at Fig. 58. Sometimes the fittings are suspended from the ceiling, the pendants being provided with a swing or swivel top so as to fasten back in the daytime. Another arrangement consists in mounting the gas lamps on the top of the stall or division posts.

Owing to the inflammable nature of such materials as hay, straw, &c.—small pieces of which are liable to be disturbed by restive horses—no naked lights should be permitted

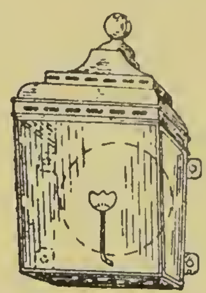


Fig. 58.

within the building. The gas burners should not be placed nearer to the ceiling than 3 feet. The service pipes should be of strong wrought iron butt-welded tubing, and laid with a slight inclination towards the main, so that any moisture collecting therein may discharge into the main and eventually find its way into the siphon boxes.

Where electricity or gas is not available as an illuminant oil or candles must be used. For this purpose wall lamps, similar to that already shown in Fig. 58, may be provided. Another very convenient arrangement is illustrated in Fig. 59. An iron bearer, running the whole length of the stable, and supported from the ceiling by suitable brackets, is fixed a little to the rear of the stalls, as indicated at A, Fig. 37. The stable lamp is suspended from the bearer by a

"carriage" or "runner," and designed to slide freely and easily from end to end of the building. The light can thus be brought immediately behind any of the stalls to suit the requirements of the moment, and adjusted to any desired

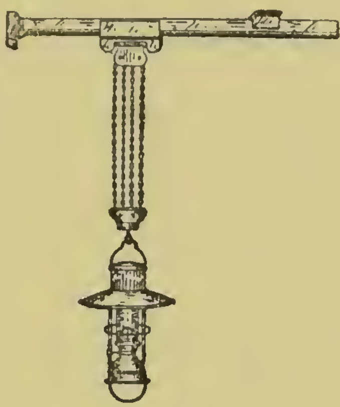


FIG. 59.

height by means of the chain and balance-weight. The lamp is provided with a polished metal reflector, and the glass protected from injury by an iron wire guard. These lamps are obtainable fitted either with a reservoir for burning oil or a socket for holding a candle.

CHAPTER XI.

PAVING.

PAVING :—The requirements of a good stable paving—Pebble paving—Its defects—Stone slabs—Granite pitchers—Asphalt — Cork pavement—Wood blocks—Method of laying same—Common bricks—Dutch clinkers — Adamantine clinkers — Terro-metallic clinkers—Staffordshire blue bricks — Selection of stable paving bricks — "Olympia" paviors—"Tebbutt's" paving —"Fiander's" pattern—Ornamental paving—Weight and covering capacity of stable paviors—Concrete paving—Average thickness—Coloured concrete—Details of laying stable floors—Paving for cow-houses, coach-houses, &c.—Construction of floors over stables.

THE paving of stables is a matter of great importance, insomuch that it exercises considerable influence on the general welfare and comfort of the animals for whose use it is intended. A slippery, absorbent, and badly laid floor is absolutely dangerous to the health and limbs of all horses, cattle, &c., that may be required to walk or stand upon it for any length of time. To ensure the utmost sanitary efficiency, not only must the material selected be thoroughly suitable for the purpose, but it is necessary that it should be so laid that urine and any other waste liquids shall be readily drained from the entire surface of the floor, and at once removed outside the building.

A good stable-paving material must be non-absorbent, durable, sufficiently hard to withstand the roughest usage, smooth but not slippery, unaffected by acids, moisture, or variations of temperature, and easily cleaned. When laid, the whole surface must be perfectly water-tight.

In order to comply as far as possible with these conditions,

various materials have been recommended and used; but the great majority of them have failed—in one or more respects—to satisfy those requirements which are found necessary for the production of a hygienic and safe paving material.

At one time a most insanitary but common form of paving consisted of hard pebbles or rounded flints laid and bedded in sand. In floors of this description the joints between the pebbles and the layer of sand beneath eventually became saturated with decomposing urine and other foul liquids, giving off most objectionable and unwholesome vapours. To remedy in some measure this defect, the pebbles were occasionally grouted in cement, but even then the resultant surface was of a most unsatisfactory character. From constant use the surface became very uneven, whilst the numerous and unequal joints did not admit of the paving being easily cleaned, and offered insuperable difficulties to the proper drainage of the building. In addition, the worn pebbles became very slippery and dangerous to walk upon. A stable paving of this class should therefore be entirely avoided.

Stone slabs or flags are sometimes used in districts where they are cheap and plentiful; but they cannot be considered as providing a suitable stable-paving material. The surface becomes very slippery, and the slabs are liable to be broken or displaced under ordinary wear and tear.

Granite paving pitchers about 10 inches by 4 inches on the face, and 6 inches deep, laid diagonally in parallel courses with proper falls on a concrete foundation, bedded and closely jointed in cement, afford a very hard and durable surface, but they are apt to become slippery with heavy and continuous use. The surface may, however, be roughened, and thereby greatly improved by forming slight diagonal grooves about 3 or 4 inches apart, and arranging them to fall into the branch channel from each stall or loose box. It is comparatively expensive in first cost; but in stables subject to constant, rough, and heavy wear, it gives fairly

satisfactory results when well set. At the same time it does not fulfil all the conditions of a thoroughly sanitary stable paving.

Small granite cubes 4 inches by 4 inches by 4 inches (sometimes known as " granite half-sovereigns "), are also used for stable paving where much rough usage is anticipated; but owing to the numerous joints the surface is not readily drained, and the general result is inferior to that of the granite pitcher paving just mentioned.

Asphalt is another material that has been used for stable floors. The surface is non-absorbent, durable, and easily cleaned; but it is much too slippery to be used with safety for such a purpose.

Within recent years there has been introduced a composite material containing a large proportion of asphalt or bitumen, and known as " cork pavement." It consists of finely granulated cork, thoroughly incorporated with bitumen, and compressed into bricks. In this admixture, the slipperiness which is the great defect of asphalt when used alone is entirely obviated, and a secure foothold is obtained by this means. After complete immersion in water for ten days, the material showed no appreciable increase in weight or bulk. It is therefore much more non-absorbent than many of the varieties of bricks which are commonly used for stable paving. The cork bricks require to be laid to proper falls on a concrete substructure, and bedded and jointed in the bituminous material specially prepared and sold for the purpose. The pavement is practically impervious to moisture, not slippery, and for stables where noiselessness is of paramount importance, it may be used with advantage.

Wood-block paving has sometimes been used in stables. It affords a good foothold to the horses, and is comparatively noiseless; but the porous nature of the material is a most serious defect. Even when thoroughly creosoted timber is used, the wood blocks are much too absorbent to be considered as providing a sanitary form of stable paving. The urine

and other waste liquids, instead of flowing freely from the surface of the floor, are in a great measure absorbed by the blocks themselves until the whole of the paving becomes saturated. The result is that the air of the stable never smells pure and wholesome, but is always more or less tainted by the ammoniacal and other hurtful vapours given off from the decomposing organic matters retained in the pores of the wood. Paving material of this description is therefore quite unsuited for such confined situations as the interior of stables, but it may sometimes be used with advantage for stable-yards and other places where it would be constantly subject to the ameliorating influences of the open air.

The blocks may be laid in the same manner as usually adopted for paving public streets. The foundation should consist of Portland cement concrete 6 inches thick laid on a 6-inch bed of hard, dry, broken bricks which have been previously well rammed. The creosoted blocks are then placed endwise of the grain with a space of $\frac{1}{4}$ inch between the courses and $\frac{1}{8}$ inch between the blocks, and the joints grouted with a mixture of creosote and pitch. For stable yards, &c., of large area, expansion joints about one inch wide should be provided at intervals to allow for the swelling or expansion of the wood, the space being afterwards filled in with the grouting mixture.

Sometimes the wood blocks are laid on an asphalt bed about half an inch thick, and resting on the concrete foundation, the whole floor being then well grouted in with asphalt, or cement and sand.

Bricks made from various descriptions of clay are much used for stable paving. These vary considerably in size, form, and degree of impermeability. For farm stables in country districts, specially selected hard common bricks are sometimes used. The general result is, however, unsatisfactory, for they are very porous, and under constant wear the surface becomes most uneven.

A small variety of brick known as *Dutch clinkers* were at one time imported from Holland, and almost universally

used for high class stable paving. They are of a dull yellow colour, very hard (the material being thoroughly vitrified), and wear with a rough surface; but they have now been superseded in England by a similar description of brick known as *adamantine clinkers.* These bricks are of a bright yellow or pink colour, whilst at the same time they are harder, heavier, and of a more regular shape than Dutch clinkers. They can be procured with sharp arrises, as in Fig. 60, or with chamfered edges, as in Figs. 61 and 62, the

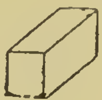
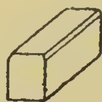


FIG. 60.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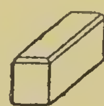
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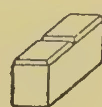


FIG. 63.


FIG. 64.

two latter being designed to give a more secure foothold. The form of brick shown at Fig. 63 is also designed for the same purpose, and is known as a "double-panel chamfered clinker." Fig. 64 shows a channel brick which is greatly used in connection with the paving bricks just mentioned.

Another similar description of brick paviors—known as "*terro-metallic clinkers*"—may also be obtained; they are made of the same shape and size as adamantine clinkers, but are almost black in colour.

Staffordshire blue paving bricks are also largely used for the floors of stables. The upper edges are usually chamfered, as in Fig. 65, so as to provide a better foothold, or else the

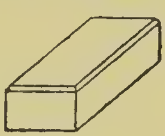
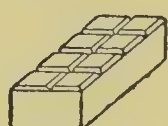


FIG. 65.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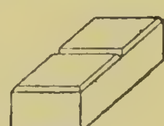


FIG. 67.

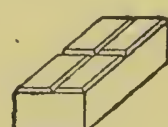


FIG. 68.

surface is further divided into a series of panels by means of V or U-shaped flutes or grooves. (See Figs. 66, 67, and 68). Bricks of this description, when of good quality, are extremely hard and durable, and absorb but little moisture.

In the selection of bricks suitable for stable paving, it is

important to remember that in all cases where indentations or grooves are formed on the surface for the purposes of affording a grip to the feet, so as to prevent any sense of slipperiness whilst the animals are walking or standing upon them, it is also necessary, for thorough sanitary efficiency, that all such grooves should fall towards the main channels provided for the removal of refuse liquids.

It will be observed that floors formed with many of the bricks already mentioned, not only have longitudinal channels but also a large number of transverse channels (as indicated in Fig. 69). Such surfaces are consequently most difficult to keep clean, for the transverse channels become blocked with dirt and other *débris*, which is eventually

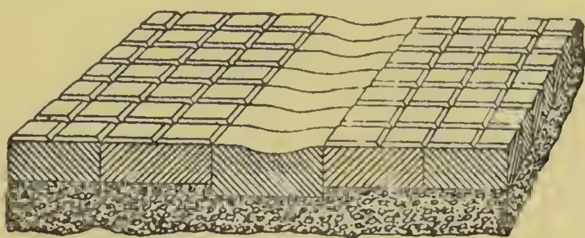


FIG. 69.

completely saturated with urine. Even with a broom and large quantities of water it is not practicable to thoroughly clean the grooves, as it will be found on sweeping the floor in the direction of one set of grooves, that the other set of transverse channels provides a lodgment for the dirt, which cannot be entirely removed by the broom. In addition to this defect, the joints between the bricks are, as a rule, formed in the grooves, so that unless the joints remain perfectly water-tight, there is a constant risk of the liquid refuse soaking into the substructure of the floor.

The form of brick shown in Figs. 70 and 71 overcomes these objections in a great measure. They are provided with one or two U-shaped grooves, so that when laid the surface is intersected by a series of longitudinal grooves falling towards

the main channel. The greater portion of the joints between the bricks being also on a higher level than the channels, there is not the same tendency for liquids to soak into the joints. Bricks similar to Fig. 70 may be obtained of a deep brown or blue-black colour, whilst the "Olympia" paving bricks (of which Fig. 71 is a sketch) are light brown

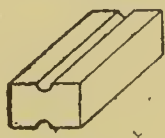


Fig. 70.

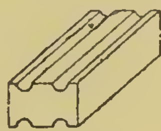


Fig. 71.

or buff in colour. Specially made splay bricks (see Fig. 72) are also obtained when it is required to lay the branch grooves at an angle with the main channel. By this means any cutting or waste at the junction is avoided.

Amongst other varieties of bricks for stable paving may be mentioned a type of brick having a series of projections ar-

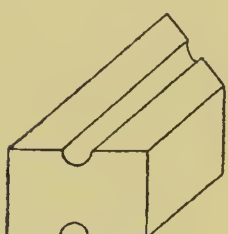


Fig. 72.

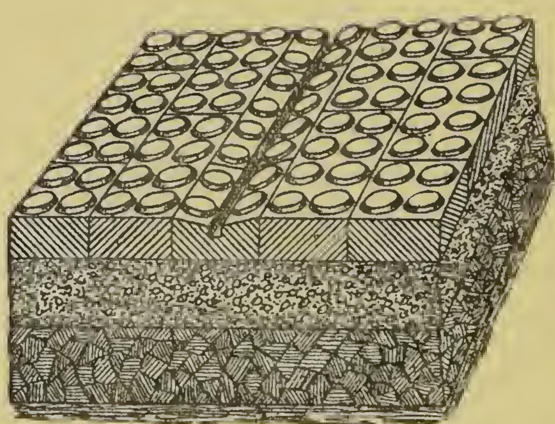


Fig. 73.

ranged on the face in order to afford the necessary foothold, whilst permitting the surface to be adequately drained.

Fig. 73 is a sketch of a pavement of this description, manufactured by Mr. J. Hamblett, and known as "Tebbutt's Patent Safety Paving." Each brick is formed with a series of circular flattened projections standing about $\frac{3}{8}$ inch above

the general surface, thus providing an equally secure grip to the hoof in whatever direction the horse is standing or walking. The projections are placed sufficiently close together that the tops of the knobs form the treading surface, and being easily drained, it is seen that for practical purposes a perfectly dry walking or standing surface is obtained.

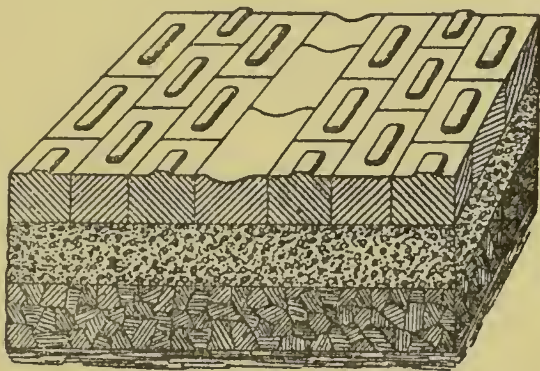


FIG. 74.

Another design, known as "Fiander's Registered Pattern Paving," is shown in Fig. 74. Each brick is formed with a raised "frog" or rectangular projection, so as to provide a non-slipping surface. The projections are spaced comparatively far apart, in order that the horses' feet may enter between them, whilst at the same time the raised portion affords the necessary grip to the hoof.

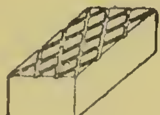


FIG. 75.

FIG. 76.

For decorative purposes the paving of the passages at the rear of the stalls is sometimes laid with bricks having a more or less ornamental pattern stamped upon them; or the ordinary plain and chamfered stable bricks may be arranged according to some geometrical design. Figs. 75 and 76 are typical

illustrations of paving bricks arranged with an ornamental pattern on the face.

Sketches of plain paviors laid "herring-bone" pattern

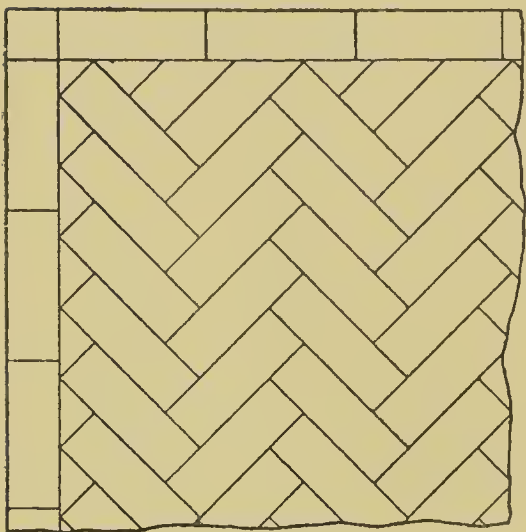


FIG. 77.

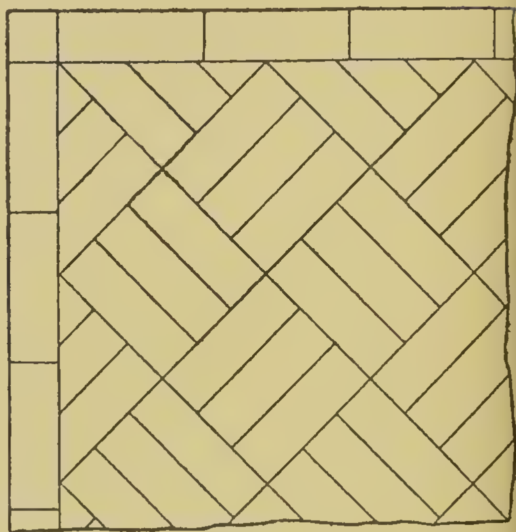


FIG. 78.

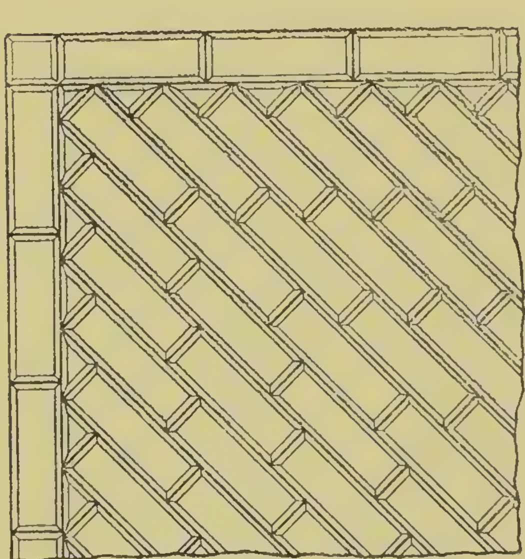


FIG. 79.

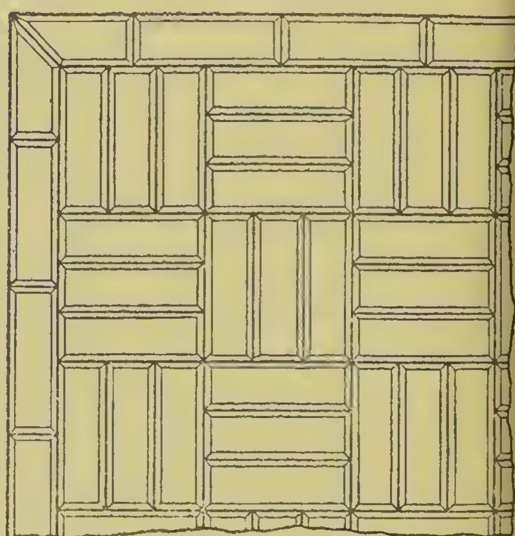


FIG. 80.

and in "small squares" are shown in Figs. 77 and 78 respectively, whilst Figs. 79 and 80 show the ordinary chamfered bricks disposed in other simple regular forms.

The dimensions, weight, and covering capacity of the different descriptions of paving bricks mentioned are as follows, viz.:—

TABLE SHOWING THE SIZE, WEIGHT, AND COVERING CAPACITY OF VARIOUS DESCRIPTIONS OF STABLE PAVING BRICKS.

Description.	Size.	Approximate Weight.	Average Number per Yard Super.
	Inches.	lbs.	No.
Cork paving bricks	$9 \times 4\frac{1}{2} \times 1$	$1\frac{1}{2}$	32
Ditto	$9 \times 4\frac{1}{2} \times 1\frac{3}{4}$	$2\frac{3}{4}$	32
Ditto	$9 \times 4\frac{1}{2} \times 2$	$3\frac{1}{4}$	32
Wood-block paving	$9 \times 3 \times 4\frac{1}{2}$	$2\frac{3}{4}$	48
Ditto	$9 \times 3 \times 6$	$3\frac{3}{4}$	48
Picked stocks, laid flat	$8\frac{3}{4} \times 4\frac{1}{4} \times 2\frac{3}{4}$	7	35
Ditto, on edge	$8\frac{3}{4} \times 2\frac{3}{4} \times 4\frac{1}{4}$	7	54
Dutch clinkers	$6\frac{1}{4} \times 1\frac{1}{2} \times 3$	$1\frac{1}{2}$	140
Adamantine clinkers	$6 \times 1\frac{3}{4} \times 2\frac{1}{2}$	2	120
Terro-metallic clinkers	$6 \times 1\frac{3}{4} \times 2\frac{1}{2}$	2	120
Staffordshire blue paviors	$9 \times 4\frac{1}{2} \times 2$	6	32
Ditto	$9 \times 4\frac{1}{2} \times 3$	9	32
Single-groove paving bricks ..	$8 \times 2\frac{5}{8} \times 2\frac{5}{8}$	4	60
Candy's "Olympia" Paving Bricks	$9 \times 4\frac{1}{2} \times 2\frac{1}{2}$	7	32
"Tebbutt's" Safety Paving Bricks	$10 \times 5 \times 2\frac{1}{2}$	$8\frac{3}{4}$	26
"Fiander's" Registered Paving Bricks	$9 \times 4\frac{1}{2} \times 2\frac{5}{8}$	$8\frac{3}{4}$	32
Ditto	$9 \times 4\frac{1}{2} \times 3$	9	32

Portland cement concrete, when properly executed, forms an excellent material for stable paving. It is non-absorbent, water-tight, smooth, jointless, not affected by heat or cold, easily cleaned, and comparatively inexpensive. At the same

time, it is neeessary to remember that Portland eement eoncrete as ordinarily made and laid is quite unsuited for the purpose. To form a stable floor of eement eoncrete which shall prove satisfaetory under eonstant and heavy wear, it is neeessary that the whole shall be eomposed of the very best materials; whilst eonsiderable eare and experienee are required to properly mix and lay the same. There are many well-known firms of eonerete workers who make a speciality of stable paving, and where concrete floors arc intended to be adopted for stables, it is desirable that the work should be earried out by a eompetent and experieneed firm. By this means good and durable work will be ensured.

Concrete for stable paving is—or should be—eomposed of well-washed granite chippings and Portland eement of the best quality, the whole being so intimately mixed together that, when thoroughly set, the finished material is as hard as granite itself. During the process of laying the concrete the surfaee must be floated and trowelled to proper falls. In addition, the surface should be formed with a series of grooves, so as to afford a good foothold for the horses, and to assist in the morc complete and ready removal of urine or waste liquids from the floor of the stable.

For coach-houses, cow-houses, and similar purposes, the concrete paving need not be more than 2 inehes thick. Stable floors for earriage horses, &e., should be 2½ inches thiek; but where heavy wear and tear is anticipated, as in tramway stables, and for heavy draught horses generally, the paving should be not less than 3 inches in thickness.

The passages and gangways at the rear of the stalls are frequently grooved to some ornamental pattern, so as to improve the appearanee of the stable. Figs. 81 to 84 are representative of the mode of grooving adopted for this purpose.

If desired, the eoncrete may also be coloured red, buff, green, &c.; but the use of eoloured eoncrete is in most eases eonfined to the floors of the passages, the stalls and loose boxes being finished in the natural grey colour of the material.

All stable paving should be laid on a firm unyielding substructure. For ordinary purposes, a foundation of 6 inches of Portland cement concrete, in the proportion of

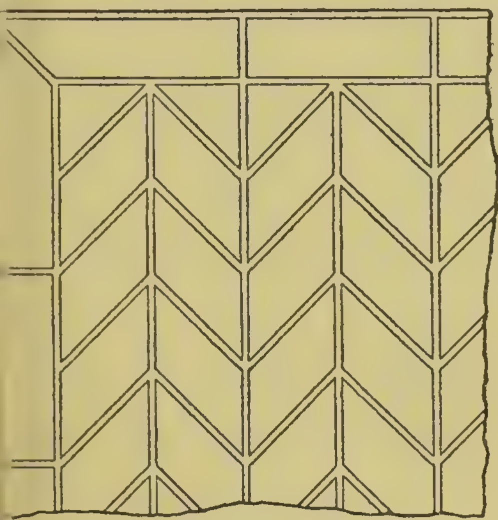


FIG. 81.

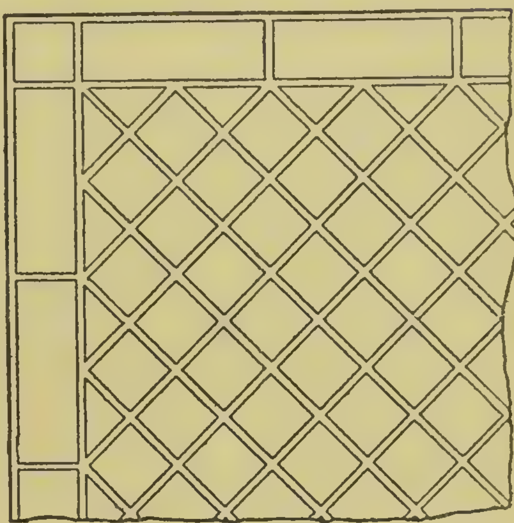


FIG. 82.

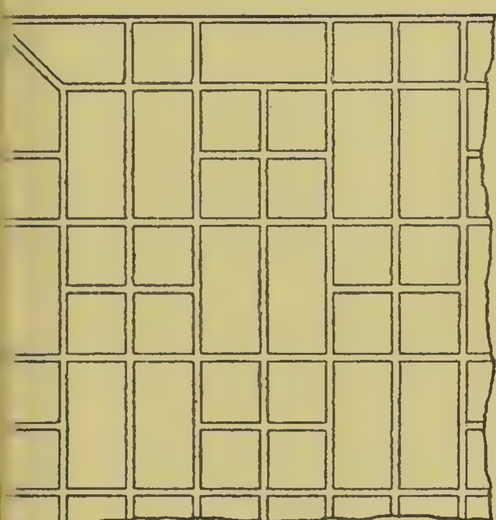


FIG. 83.

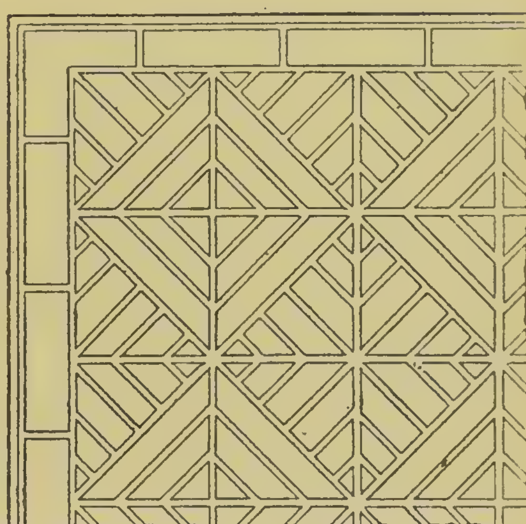


FIG. 84.

6 parts aggregate to 1 of cement, laid on a layer of hard, dry, broken brick rubbish, 6 inches thick, and well rammed, will afford a good base to receive the paving. Fig. 37 shows

6 inches of concrete foundation with a 6-inch layer of broken brick rubbish under; whilst Figs. 85 and 86 are sections through plain and chamfered brick stable paving respectively laid on a similar foundation.

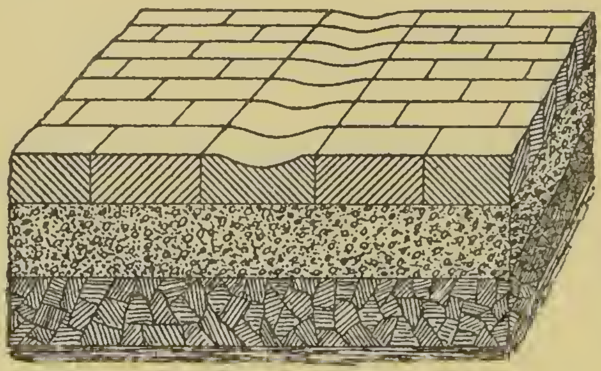


Fig. 85.

The general conditions which should be fulfilled by a satisfactory pavement for cow-houses are essentially the same as those already mentioned for stables (except that the floor will not be subject to the heavy wear and tear of iron-shod hoofs), and the same remarks respecting the suitability

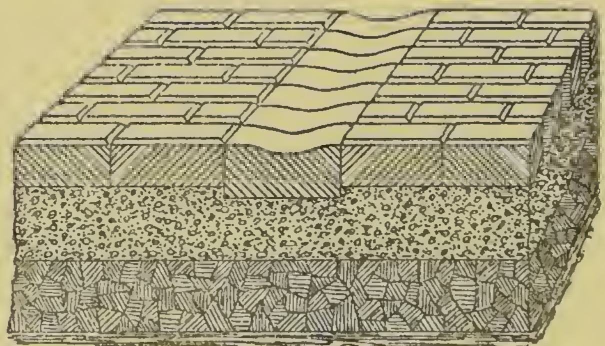


Fig. 86.

of the different materials for paving purposes will apply in this case. Usually it will be found that the most satisfactory material for the floors of cow-houses is Portland cement concrete when properly laid.

Stable-yards, coach-houses, &c., are also paved with the same description of materials as those already described, and currented to the surface channels or gullies. Where plain or grooved bricks are used, they are frequently laid to ornamental patterns similar to those shown in Figs. 77 to 80.

The floors of rooms or stores built over stables should be so constructed as to prevent any emanations penetrating from below, and so vitiating the air of the upper story. If the rooms are used for living or sleeping apartments, it need scarcely be added that this precaution is necessary for health. Where they are used as stores for fodder, it is equally desirable that the food should not be tainted with effete and impure organic matters arising from the occupied stable beneath.

In some cases the overhead hay-loft is entered from the stable through an opening in the floor, whilst other openings are also provided over the mangers so that the hay may be thrown directly into them. Such a method minimises the labour of feeding; but the sweet and wholesome flavour of the fodder is in some degree sacrificed and spoilt by contamination with the vitiated air from below.

An ordinary wood floor for overhead stores should have the flooring boards grooved, tongu d, and laid with close joints. The under side of the joists should be finished with a lath and plaster ceiling. In order that the horses may not be disturbed by the noises overhead, it is a good plan to provide "sound-boarding." This consists of 1-inch rough deal boards laid between each joist and nailed to 2-inch by $\frac{1}{2}$-inch rough fillets, the whole supporting a 3-inch layer of "pugging," made with lime mortar and chopped hay mixed together.

A very satisfactory floor is obtained with Portland cement concrete supported on rolled iron joists, or one of the numerous forms of fire-proof floor which have been introduced from time to time may be adopted. The soffit of the floor

is plastered, or rendered smooth with cement. Where the rooms above are intended for living or sleeping purposes, they may be finished with boarding or wood blocks. For stores, the surface is usually rendered with cement, but it may be finished with tiles or asphalt.

CHAPTER XII.

DRAINAGE.

DRAINAGE :—Solid matters to be removed by hand—Removal of liquid refuse—Underground drains in stables—Surface channels—Drainage of military stables—Cast and wrought-iron gutters—Grooving and channelling for concrete floors—Covered channels—Flushing facilities —Gradients for stable floors—Trapped gullies—Stable drainage to be distinct from house drainage—Remarks on laying drains—Cesspools—Drainage of cow-houses—Concrete floors—Manure pits.

THE principal materials used for stable paving having been considered, it becomes necessary to ascertain the best method of effecting the removal of the solid and liquid refuse. From the inevitable circumstances of the case, the excrement and other solid waste matters must be removed by hand at frequent intervals, in order that the building may be maintained in a permanently sanitary condition; but with regard to the liquid portion of the refuse, particularly urine, it is essential that adequate means should be provided for its immediate removal, owing to the rapid decomposition which takes place, especially if some degree of heat and moisture be present.

Frequently the liquid refuse is removed from stables by means of underground drains, the floor of the stalls and loose boxes being currented to one or more surface gullies or stable pots conveniently situated for the purpose within the building. The trapped gullies inside the stable are in many cases directly connected with the general drainage system, but such a method cannot be looked upon as affording the best means of removing stable sewage. The seal of each trap consists for the most part of stagnant

urine, giving off unwholesome ammoniacal vapours, so that the air of the stable seldom smells fresh and pure.

Another grave danger to be apprehended from such a system of drainage is that the trap or seal of the stable pots may be destroyed by evaporation or siphonage, thus affording an unrestricted entrance of sewer gas into the interior of the building.

In some instances the internal surface gullies are *trapless*, and discharge into a trapped gully immediately outside. One of the best arrangements of this description is shown in Fig. 87, which is an illustration of "Ward's improved and

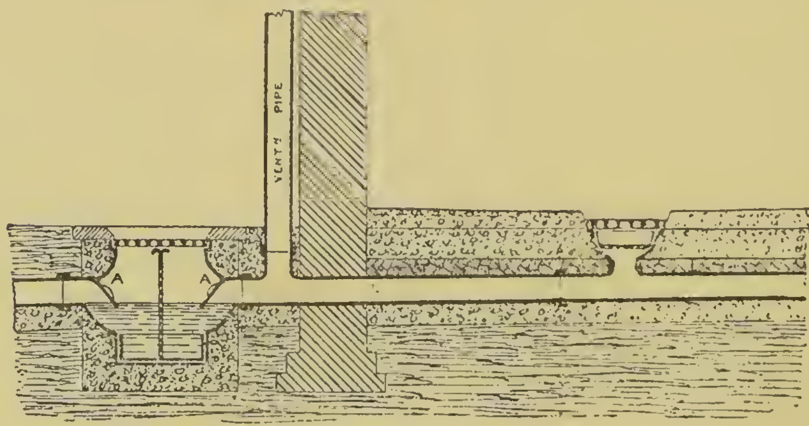


Fig. 87.

registered system of stable drainage." The internal trapless gullies are provided with perforated baskets to retain the straw and other solids passing through the surface gratings, the drain discharging into a trapped gully outside. Removable caps are provided at A A, to admit of the drains being inspected and cleaned when necessary. The stable drains are completely disconnected from the general drainage system by means of the intercepting trap or gully placed immediately outside the building.

From a sanitary standpoint, there are some objections to any arrangement of underground drains within stables for the removal of liquid refuse. For permanent efficiency

it is therefore considered that the most satisfactory method of draining the interior of stable buildings is by means of surface channels discharging the whole of the waste liquids directly into trapped gullies placed outside for the purpose.

The drainage of military stables is effected entirely by means of shallow surface channels which are carried directly through an external wall and continued for a distance of 12 feet from the building before discharging into a gully trap. Such an arrangement ensures a frequent cleansing of the gutters—both inside and outside the building—by the stablemen, as any accumulation of refuse would be at once detected. The short length of surface channel outside the stable is designed to arrest the particles of straw or other matters which would otherwise enter the gully and tend to block the drains. In this respect it fully answers the purpose for which it is intended, but for private stables, any external surface channels would generally be unsuitable, on account of the untidy appearance given to the stable yard.

Where rough and careless usage may generally be expected, as in stables for farms, tramway companies, breweries, general carriers, &c., it is necessary that the drainage arrangements should be of the simplest description, with an entire absence of movable gratings or loose perforated covers within the building, as such articles are liable in course of time to get broken or lost. The whole of the internal drainage should therefore be conducted to the outside by means of open surface channels, as shown in Figs. 1, 41, 43, and 44, the floor of the stable being laid to proper falls towards the channels.

Figs. 73, 74, 85, and 86 are sectional sketches through the floor of a stall, showing the general arrangement of different varieties of paving bricks laid with an open channel in the centre. Figs. 88 and 89 also illustrate other forms of open-channel drainage for stalls, in which cast or

wrought-iron gutters, firmly embedded in concrete, are substituted for brick channels. The surface of the iron guttering is either roughened or formed with a series of slight projections to prevent the horses slipping thereon.

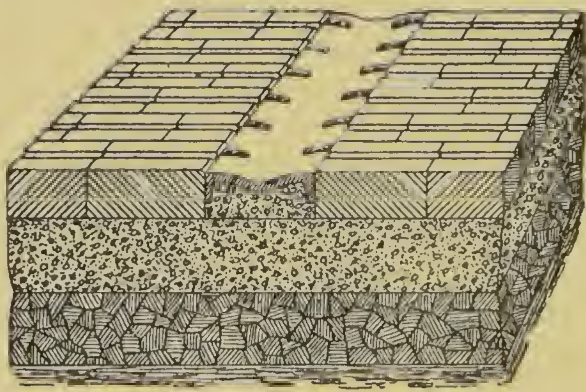


Fig. 88.

Open iron channels are, however, apt to be slippery, whilst if the surface of the iron is too much roughened or indented, the horse's limbs are liable to be bruised and cut in the act of getting up or lying down.

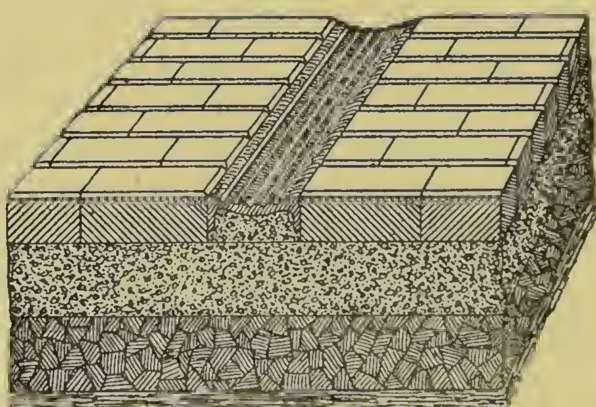


Fig. 89.

Fig. 90 is the plan of a stall showing the form of grooving and channelling sometimes adopted for a concrete stable floor. The surface is divided into a series of small squares by means of longitudinal and transverse grooves

spaced about 5 inches apart. The whole of the longitudinal grooves are arranged to fall directly towards the main channel. The greatest objection to this form of grooving for stalls and loose boxes is the difficulty experienced in thoroughly cleansing the floor owing to the numerous cross-grooves.

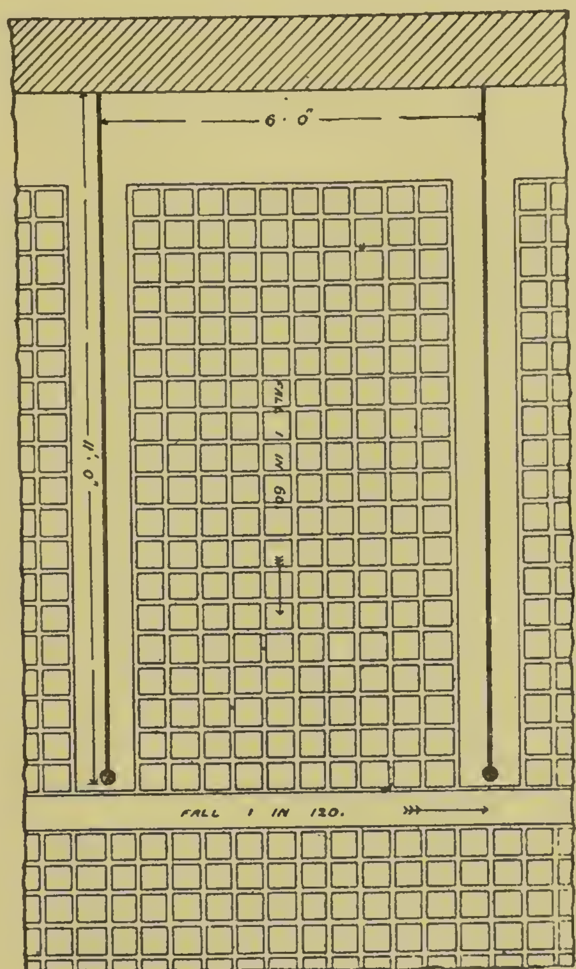


FIG. 90.

A method of grooving and channelling frequently used for stalls with concrete floors, as laid by Messrs. Wilkinson & Co. and other firms of concrete specialists, is shown in

Fig. 91. The grooves fall towards a central channel, which in its turn empties into the main channel at the rear of the stalls.

Fig. 92 shows a modification of the form just described, known as "Ward's patent grooved and channelled granite

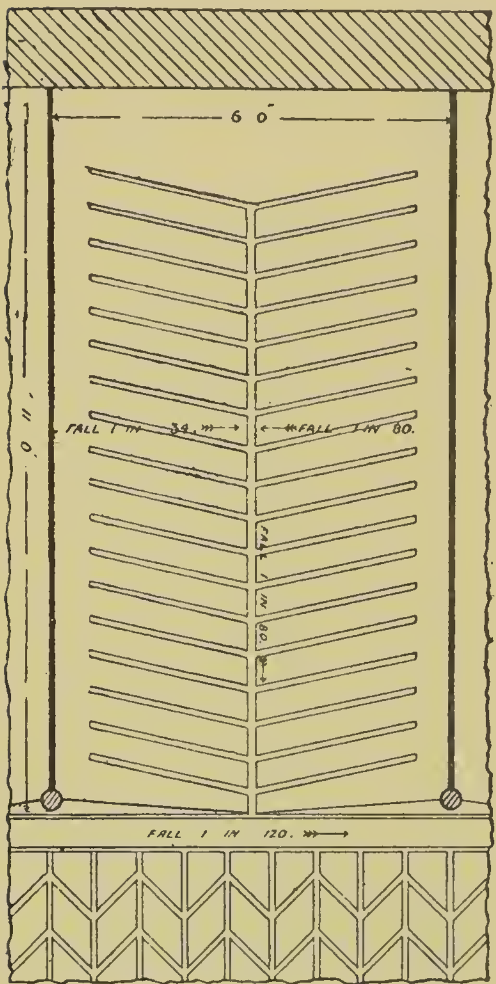


Fig. 91.

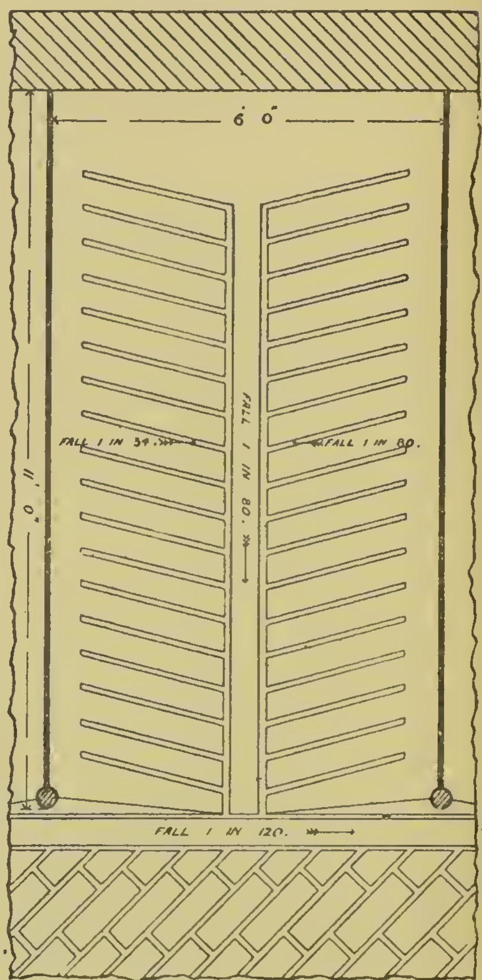


Fig. 92.

concrete stable paving." Instead of one central stall channel two grooves are substituted, having a plain surface of concrete between them. Each of these small channels receives the drainage of half the "standing," and empties directly into the main channel at the rear. By this means the centre

portion of the stall floor—where the heaviest wear and tear is experienced—is quite unbroken by grooves or channels, and it is considered that a greater strength of material is obtained at this point.

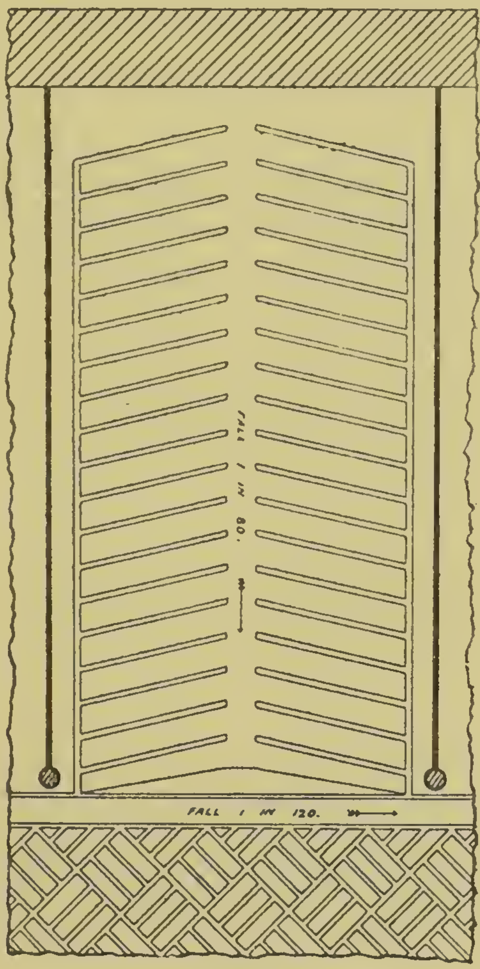


FIG. 93.

Another arrangement of grooving and channelling is shown in Fig. 93, the object being to avoid the use of central longitudinal channels altogether, and so obtain increased strength of material at the centre of the stall floor. The paving is laid so as to slope slightly from the centre towards the sides, the grooves falling into a small

longitudinal channel at each side. In order that the general slope of the stall paving may be as small as possible, the transverse grooves are made very shallow at the highest level, and gradually deepening as they reach the stall channel. This last form of grooving is, however, but little used, the methods usually adopted being those shown in Figs. 91 and 92.

The indentations or grooves in a concrete floor should be of a shallow V or saucer-shaped section, as indicated in Fig. 94, about $1\frac{1}{4}$ inches wide and $\frac{1}{2}$ inch deep. Grooves of a section similar to that illustrated—having no internal angles—are readily cleaned with a broom. The main

Fig. 94.

Fig. 95.

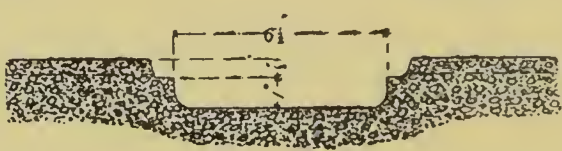


Fig. 96.

channel at the rear of the stalls should be comparatively wide and shallow, so that it may not be a source of danger to horses when passing over it. Figs. 95 and 96 are sections showing the form of main channel generally used in connection with the grooving and channelling illustrated in Figs. 91 and 92 respectively. In both cases the width of the main channel is $6\frac{1}{2}$ inches, with a total depth of $1\frac{1}{2}$ inches. On each side a splayed rebate about $\frac{1}{2}$ inch deep is formed to receive the various grooves from the stalls and gangways.

In better class stables, where the unsightliness of a large open main channel would be considered objectionable, and where a certain amount of care and cleanliness can also be ensured, a very satisfactory arrangement may be obtained

by covering the main channel with a perforated movable cast- or wrought-iron cover, the whole of the surface channels within the stalls or loose boxes being at the same time left open (see Figs. 42 and 47). The section of main channel suitable for such a purpose is shown in Fig. 97, the upper surface of the movable grating being placed about ½ inch below the floor surface, so as to allow the grooves of the stalls and gangway to discharge over it.

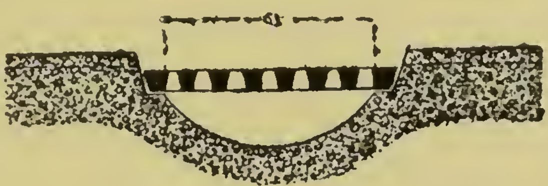


FIG. 97.

FIG. 98.

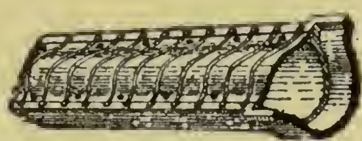


FIG. 99.

Where covered main channels are used in connection with brick paving, it is usual to construct both the cover and channel of cast or wrought iron, as shown in Figs. 98 and 99. When the stalls are drained by means of open

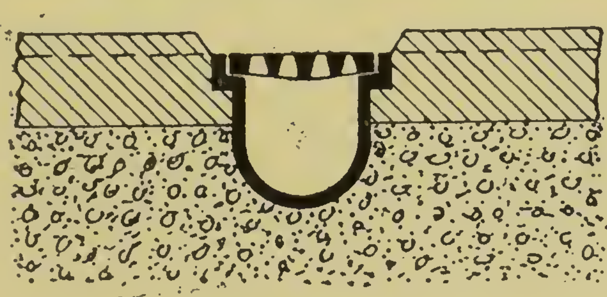


FIG. 100.

shallow channels, as seen in Figs. 74, 85, 86, 88, and 89, the grating of the main channel should be fixed at a slightly lower level than the general floor surface, so that the stall channels may discharge over it (see Fig. 100).

Generally, the invert of the main channel is parallel with the surface of the floor, both being arranged with a certain definite fall towards the gully outside the building. Iron channels fitted with a movable grating may, however, be obtained, in which the necessary fall is provided in the gutter itself, the depth of the channel being gradually increased towards the outfall, so that the cover and the adjacent surface of the floor remain level throughout. They are made in 2, 4, and 6-feet lengths with a fall of 1 in 120 (1 inch in 10 feet). Fig. 101 shows an iron channel having a depth of 3 inches and $3\frac{6}{10}$ inches respectively at its upper and lower ends, thus giving a difference of level on the invert of $\frac{6}{10}$ inch in a length of 6 feet.

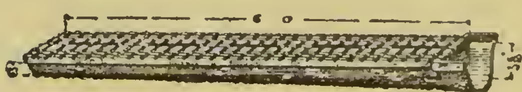


FIG. 101.

In some instances the owners of horses require that the channels of the stalls and loose boxes, as well as the main channels, shall be provided with a perforated cover, as indicated in Fig. 45. By this means it is considered that the floor approximates more nearly to a plane surface and that a slight saving of straw results, insomuch that the portion over the covered channel does not become fouled by the liquids flowing beneath, as in the case of an open channel. If desired, the stall channel, as well as the main channel, may be formed with covered iron gutters having a self-contained fall on the invert, so that a practically level floor is obtained.

Wherever covered channels are adopted the gratings should be frequently taken up, so that both the channel and cover may be thoroughly cleansed. It is an excellent plan to provide facilities for flushing the entire length of main channel at stated intervals, either by hand or by means

of an automatic flushing cistern. Such an arrangement is indicated in Figs. 42, 43, 44, 45 and 47. When covered channels are used for the stalls they may be continued the full length of the stall, and provided with a flushing pipe at the head of each channel. It should, however, be borne in mind that these flushing arrangements must only be considered as supplementing—and not taking the place of—the frequent removal of the channel grating for the thorough cleansing of the whole by hand.

Before being laid, the ironwork of all surface channels, &c., should be well coated by the Dr. Angus Smith process, so as to protect the metal from corrosion. In this process the ironwork is first thoroughly cleaned from rust and afterwards dipped—at a high temperature—in a mixture of coal-tar, pitch, and linseed oil, so that the entire surface is covered with a tough coating of bituminous material.

The gradients that may be given to the floors of stables, in order that the surface may be properly drained, will depend in some degree on the nature of the paving material employed. For instance, a smooth, impervious surface of well-laid concrete would be thoroughly drained by a much less fall than would be found necessary for a floor formed with wood blocks.

In all cases, whatever the material used, it is desirable that stable floors should be formed with as little fall as possible, consistent with the provision of an efficient draining surface. It will be readily understood that horses rest much better, and are altogether more comfortable, when standing or lying on a comparatively level plane than on a steep slope. Where they are compelled to stand for any length of time upon the floors of stalls which are laid with excessive gradients from front to rear, a painful strain is brought to bear upon the hind quarters of the animals, so that they will frequently be found endeavouring to stand diagonally or at right angles to the slope in order to obtain some relief. Satisfactory results will, however, generally be obtained by

arranging the stall floors to be laid with a total fall from front to back of 1½ to 2½ inches.

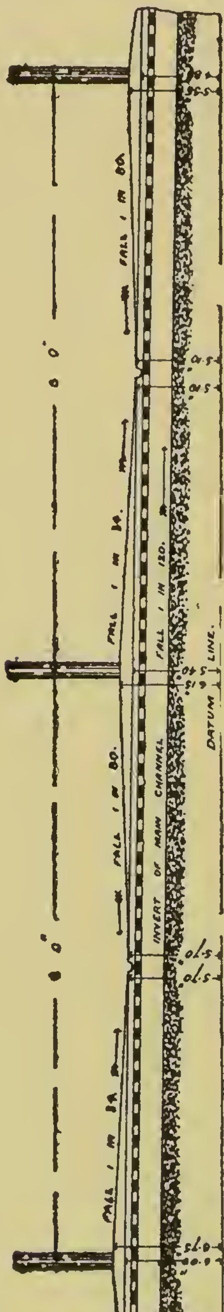


FIG. 102.

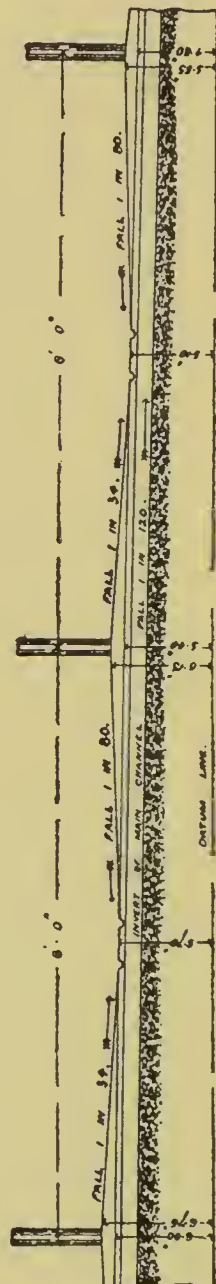


FIG. 103.

Gradients which do not exceed the amount of fall mentioned are practically inappreciable for horses standing or

lying upon them, and will be found to occasion no inconvenience. At the same time, sufficient fall is thereby obtained in the length of the stall to admit of the proper drainage of any material having a fairly smooth and non-absorbent surface.

For stalls and loose boxes paved with brick or granite, a fall of 1 in 60 (1 inch in 5 feet) is considered sufficient; in a stall 10 feet long this would represent a difference in level between front and back of 2 inches. If necessary, this fall might be increased to 1 in 48 or 1 in 50 for farm stables and other buildings of a similar description. A slope of 1 in 80 ($1\frac{1}{2}$ inches in 10 feet) will usually suffice for stalls having concrete floors. With regard to the main channel at the rear of the stalls and loose boxes, this should have a fall of not less than 1 in 120, or 1 inch in 10 feet.

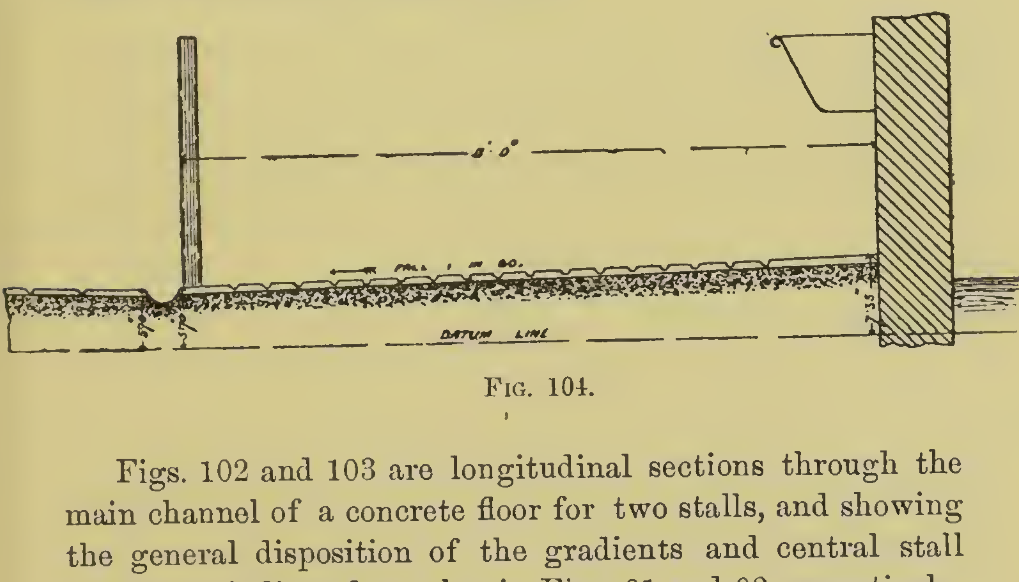


FIG. 104.

Figs. 102 and 103 are longitudinal sections through the main channel of a concrete floor for two stalls, and showing the general disposition of the gradients and central stall grooves as indicated on plan in Figs. 91 and 92 respectively. The main channel in Fig. 102 is provided with a movable perforated cover. A longitudinal section through one of the central stall channels is also shown in Fig. 104.

In the foregoing illustrations it will be noticed that the concrete floor has a fall of 1 in 80 ($1\frac{1}{2}$ inches in 10 feet) from front to back, and the main channel a fall of 1 in 120. One side of the stalls is given a fall of 1 in 80, whilst the

opposite side has a fall of 1 in 34, so as to make an allowance for the general slope of the stable floor in the direction of the main channel. On the other hand, should the covered main channel at the rear of the stalls be arranged with a self-contained fall (as in Fig. 105), the gradient from front to back of stall would be 1 in 80 as before, whilst both sides of the stalls would be arranged with a fall of 1 in 80 towards the central grooves. The invert of the main channel would have a fall of 1 in 120, the top being placed perfectly level.

From time to time many varieties of trapped gully have been specially designed to receive stable sewage. Most of them consist of a modification of the ordinary siphon trap, with the addition of a catch basket or grating to receive and retain the particles of straw, &c., which would otherwise be

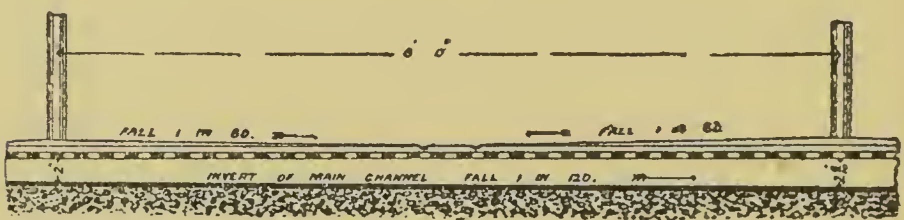


FIG. 105.

carried by the liquid sewage from the stable into the general drainage system. Where such means are not adopted to prevent the short lengths of hay and straw entering the drains, much inconvenience frequently results, as the fibrous matters readily cling to the sides of the pipes (especially if the surface is in the slightest degree rough or uneven), and so form the nucleus of continual stoppages.

Fig. 106 shows a simple form of trapped gully with a catch basket under the surface grating. Inside the stable the end of the main channel is arranged with an iron shoe, fitted at one end with a hinged grating and a sensitive flap valve at the other, the whole discharging over the trapped gully outside. The coarser solids are retained by the internal grating, whilst the flap valve prevents the entrance of air

currents through the shoe. Any pieces of straw passing the gully grating are retained by the catch basket immediately below. The solid matters should be frequently removed from the catch basket, and the gully thoroughly cleansed by hand.

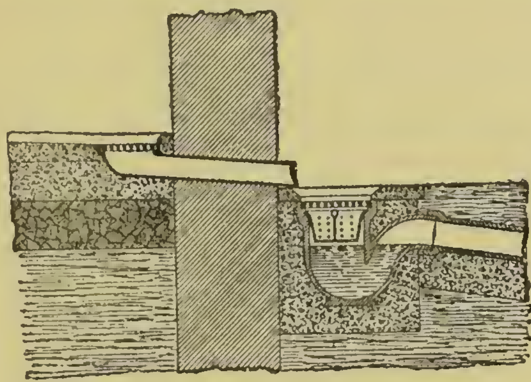


FIG. 106.

A slight modification of the preceding arrangement is shown in Fig. 107. The yard trap is provided with an extension piece or gully top, in order that the shoe may

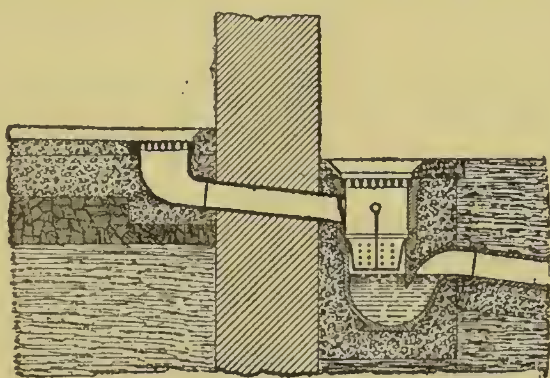


FIG. 107.

discharge below the surface grating and so avoid the unsightliness of stable refuse collecting on the grid at the floor level.

The form of trapped gully shown in Fig. 87 may also be arranged with satisfactory results in a somewhat similar manner to that just described.

Cottam and Willmore's taper gutter, with gully trap and silt pot is illustrated in Fig. 108. The main channel from the stable, being provided with a covered grating throughout its length, is carried direct through the wall

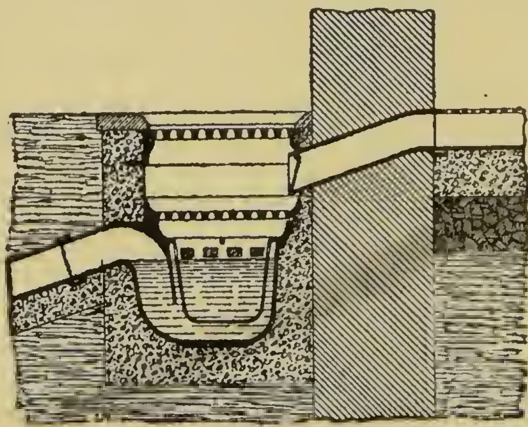


FIG. 108.

and discharges over the gully as shown. The outer end of the channel pipe is fitted with a flap valve to prevent back draught.

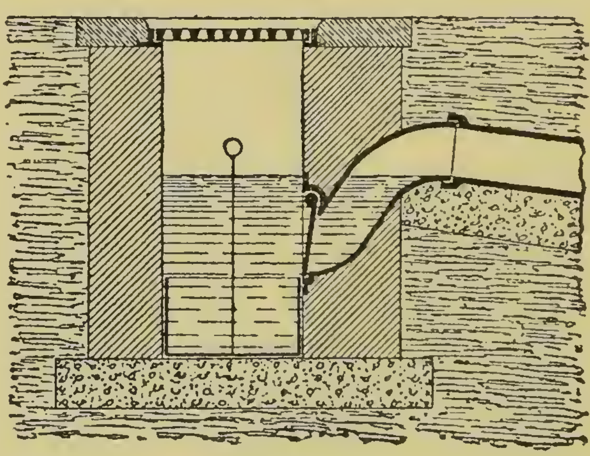


FIG. 109.

When it is required to remove quantities of liquid refuse gathered from a comparatively large area, as in stable yards, &c., a surface gully similar to that shown in Fig. 109 is frequently used; the bottom is formed with concrete and

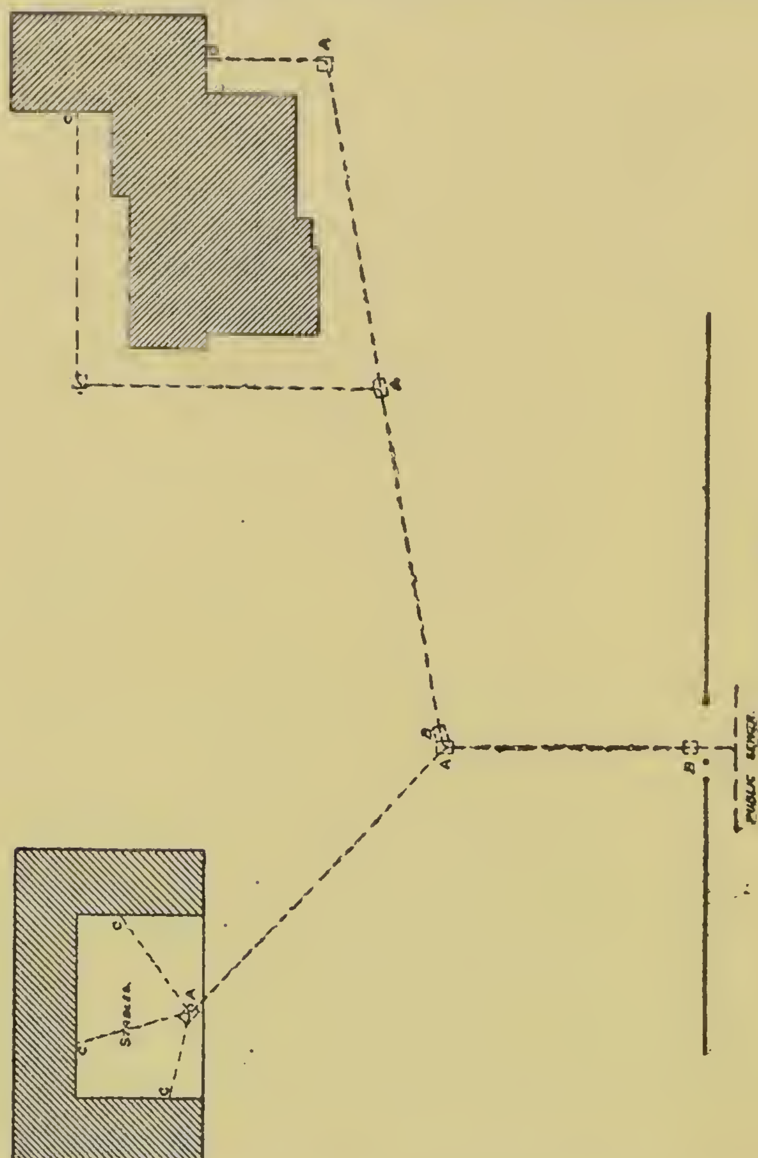
the sides of brickwork in cement, finished on the face with cement rendering $\frac{3}{4}$ inch thick. A cast-iron siphon is securely built into the side of the pit in order to form a trapped connection to the drain. This outlet from the gully is provided with a hinged grating, so that the pieces of straw, &c., are retained within the pit. The yard gully shown in the sketch is fitted with an iron silt bucket, but for large gullies of this type the silt bucket is omitted, and the sides of the pit gathered over so as to reduce the opening at the top to the same dimensions as the surface grating.

Stable drainage should be kept entirely distinct from the ordinary house drainage system. Wherever practicable it should be carried direct to the public sewer with a separate outfall, the usual disconnecting chamber being, of course, provided at that point.

When an independent outfall cannot be so arranged, a disconnecting chamber should be placed at the junction of the stable and house drains, as indicated in Fig. 110. This is essential, insomuch that stable sewage, unlike ordinary house sewage, consists in a great measure of urine in an almost undiluted form. Large quantities of ammoniacal and other gases are, therefore, liable to be given off during its passage through the drains, and if the stable sewage is not completely cut off from the house drainage these penetrating and unpleasant odours are liable to pass through any insufficiently trapped gullies situated near the house.

The whole of the drains must be laid in perfectly straight lines, with an even gradient from point to point. Inspection chambers should be provided at every change of direction, and also at a distance of about 200 feet apart on any long line of drain, so that every portion of the system may be accessible by means of drain rods. The diameter of the pipes should be as small as possible consistent with the volume of sewage that must be removed; they should be laid with good self-cleansing falls, so that a velocity of not less than 3 feet per second is obtained when the depth of

the stream of sewage is one-fourth the diameter of the drain through which it is passing. It is a good practice to provide an automatic flushing cistern at the head of the stable drain or drains, so that they may be periodically flushed and



Reference Table.

A = Inspection chamber. B = Intercepting chamber with fresh-air inlet.

C = Ventilating shafts or foul-air outlets.

FIG. 110.

cleansed, say once a day. The drainage system should be ventilated throughout; a fresh-air inlet being provided at the intercepting chamber, and foul-air extraction shafts at the head of each drain. For further information respecting

the construction of drains and other matters connected therewith, the reader is referred to the author's handbook, 'Sanitary House Drainage, its Principles and Practice,' * where the subject is dealt with in greater detail.

In country districts, where no system of public sewers is available, the stable drainage should be carried to a cesspool placed in the stable yard, or at some convenient point in the vicinity. The pit should be from 10 to 12 feet deep and 6 to 8 feet in diameter, the bottom being formed with Portland cement concrete not less than 12 inches thick; the sides should be steined with hard well-burnt bricks built in cement and not less than 9 inches thick. The brick steining may also be backed with 6 or 9 inches of well-tempered clay puddle. The top of the cesspool should be arched over with brickwork 9 inches thick in cement. A strong iron manhole cover and frame should be provided for convenience of access at any time. The whole of the interior must be thoroughly well rendered with cement about $\frac{7}{8}$ inch thick, so that it may be perfectly water-tight. It should also be well ventilated by means of a ventilating manhole cover, or when such an arrangement would be likely to prove objectionable owing to its proximity to any inhabited buildings, a low-level mica flap fresh-air inlet must be provided, together with a foul-air extracting shaft about 9 inches in diameter. The contents of the cesspool will require to be emptied at stated intervals.

The general principles involved in the drainage of cow-houses are precisely similar to those already discussed for the proper drainage of stables; but the arrangement of the surface drainage from the stalls is slightly modified to suit the necessities of the case. Fig. 111 is the plan of a stall or "standing" for two cows, showing the mode of grooving and channelling which is sometimes adopted for floors of brick or concrete. The numerous transverse grooves are

* 'Sanitary House Drainage, its Principles and Practice,' by T. E. Coleman, Mem. San. Inst., 6s., E. and F. N. Spon, Ltd., London.

objectionable, as they render it difficult to properly cleanse the surface.

A concrete floor having a central stall groove connecting a series of transverse grooves in the manner already shown

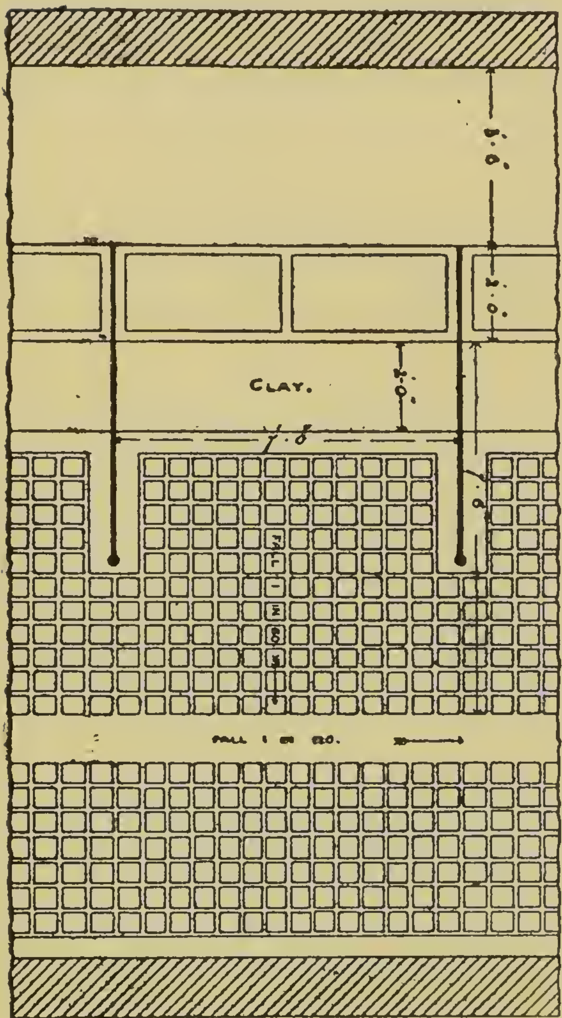


Fig. 111.

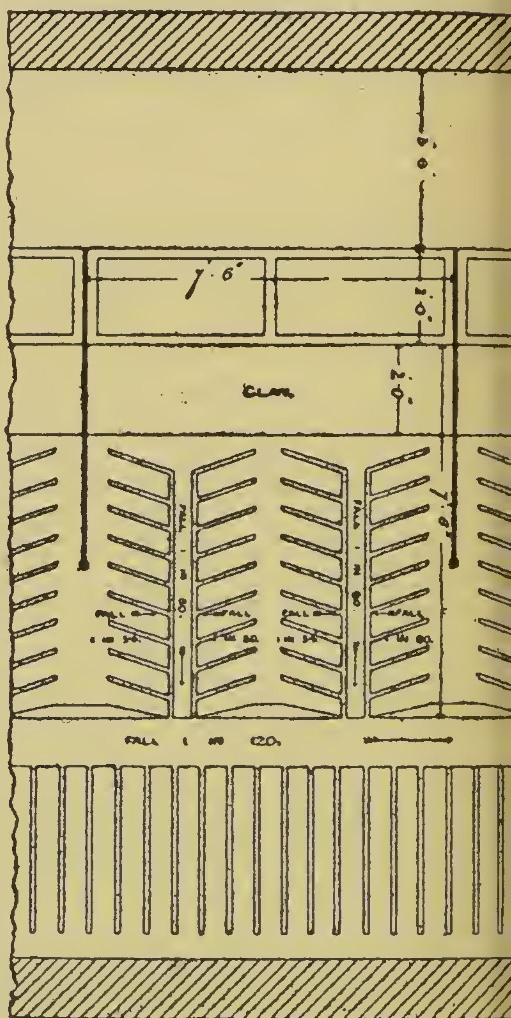


Fig. 112.

in Fig. 91 has been largely adopted. The floor has a fall of 1 in 80 from front to rear, the sides having gradients of 1 in 34 and 1 in 80 respectively, whilst a fall of 1 in 120 is given to the main channel.

Fig. 112 is a sketch showing Messrs. Ward and Co.'s

patent concrete paving for cow-houses. The general plan of the stall grooves is the same as that already described in Fig. 92, except that, instead of one, there are two complete sets of longitudinal and transverse grooves provided to each

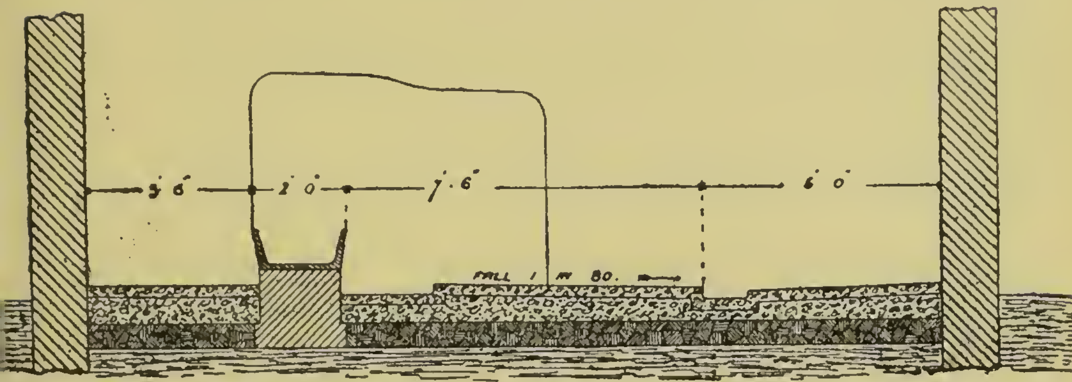


FIG. 113.

stall, so that the standing place of each animal may be separately drained into the channel at the rear.

Fig. 113 is a transverse section through a cow-byre showing the general arrangement. The stall floor is raised from 2 to 3 inches above the level of the gangway or passage,

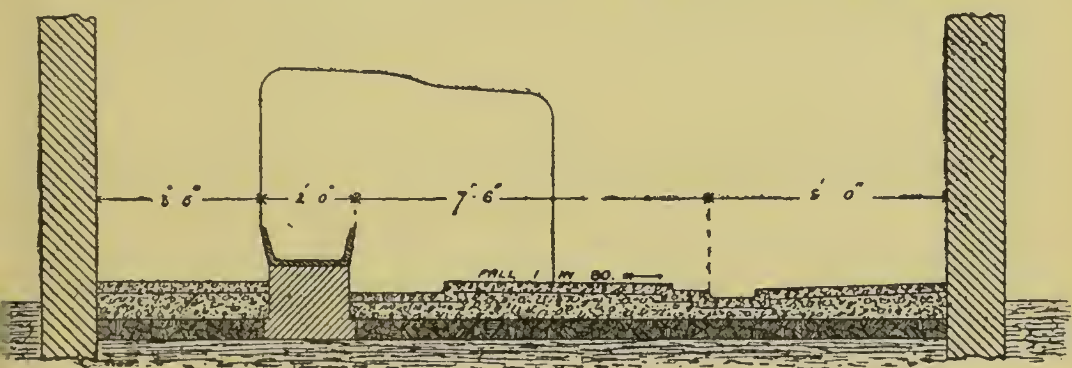


FIG. 114.

and a shallow sinking, about 4 inches deep and 2 feet wide, is formed in the floor directly in front of the feeding troughs (see Figs. 111, 112, 113, and 114). This shallow trough is afterwards filled up to the floor level of the stall

with prepared clay, so as to provide a comparatively soft surface for the fore-legs and feet of the cattle. In many cases the sinking is omitted, and the concrete or brick paving of the stall continued up to the feeding troughs; but unless the floor is well littered with straw bedding, the animals' knees are liable to be bruised and injured when lying down.

An alternative section through a cow-house is given in

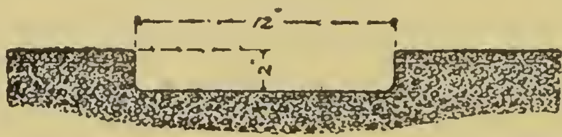


FIG. 115.

Fig. 114. It will be noticed that a "step" about 9 inches wide and 3 inches high is formed between the main channel and the rear of the stalls. This step is intended to receive the excrement or droppings from the cows, so that the floor of the stall itself is kept quite clean, whilst the main channel is not blocked by the solids.

The main channel at the rear of the stalls should simply be an open shallow gutter, made sufficiently wide to allow the attendant to clear away with a spade any solid matters

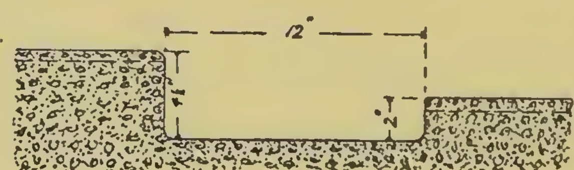


FIG. 116.

that may accumulate within it. A channel 12 inches wide and 2 inches deep will be found sufficient for this purpose, the sections usually adopted for concrete floors being shown in Figs. 115 and 116. Where the stalls of the cow-house are paved with bricks, &c., cast-iron channels of similar section to those just mentioned are frequently used (see Fig. 117). In all cases the main channel should be arranged to dis-

charge directly outside the building over a trapped gully in a somewhat similar manner to that already described for stables.

A manure pit must be provided in some convenient position for the reception of stable refuse. It should be placed well away from any inhabited buildings, and if possible about 40 feet away from the stables themselves. The floor of the pit may be formed with concrete, the surface being rendered with cement and laid to proper falls, so that the liquid sewage drains into a gully trap placed immediately outside, as shown in Fig. 1. The opening through the wall in this instance is protected with a close grating, so as to prevent loose straws, &c., passing into the gully. Generally the walls

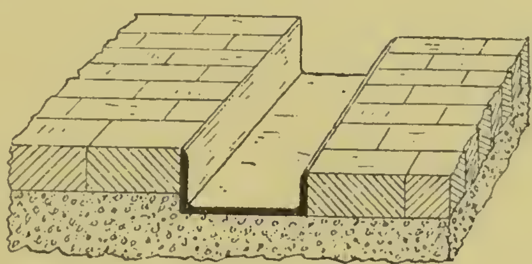


FIG. 117.

are built of brickwork, 9 inches thick, 2 feet 9 inches high, well rendered with cement on the inside, and finished on the top with a brick or stone coping.

For the metropolis it is laid down in the by-laws of the London County Council that no dung pit shall be contiguous to the walls of any human habitation. The manure pit must also be so arranged that a portion of one side is removable, so that the interior may be readily cleansed.

A further regulation enforced by the same authority states that no dung pit must have a capacity of more than 2 cubic yards unless the same is emptied at least every forty-eight hours. In the interests of the public health it would be advantageous if such precautionary measures were insisted upon in all large towns and thickly populated districts.

CHAPTER XIII.

ROOFS.

Roofs:—General construction—Collar-beam roofs—Table of scantlings for various spans—King-post trusses—Queen-post trusses—Iron roofs—Sizes required for rafters and tie rods—Composite roof trusses—Pitch or slope of roofs—Details to be observed in covering roofs—Galvanised sheet iron used for cheap buildings.

The roofs of stables are generally constructed of wood and covered with slates or tiles. Where ceilings are provided it is convenient to use timber trusses; but for open roofs iron trusses are to be preferred on sanitary grounds, owing to the non-absorbent nature of the material. Open roofs supported on iron trusses also provide a much lighter and neater appearance to the interior of the building than can be obtained with timber trusses. The ironwork should be thoroughly well painted to prevent corrosion, and periodically overhauled and repainted, in order that the whole may be maintained in a sound condition.

Fig. 25 shows a collar-beam roof suitable for an ordinary stable of 18 feet span. It is covered with $\frac{3}{4}$-inch boarding and countess slating. The rafters are spaced 12 inches apart, and tied with a collar-beam at one-quarter the height of the roof.

The following table shows the scantlings necessary for collar-beam roofs, with ceiling on the under side, for spans up to 18 feet:—

Table of Scantlings for Collar-beam Roofs when Tied at One-quarter the Height of the Roof, and Ceiled on the Under Side.		
Span.	Rafters 12 inches apart.	Collar Ties.
feet.	inches.	inches.
10	4½ × 2¼	4¾ × 2
12	5 × 2¼	5½ × 2
14	5½ × 2½	6 × 2
16	6 × 2½	6½ × 2
18	6½ × 2½	7 × 2

For spans exceeding 18 feet and up to 30 feet, the roofs when ceiled on the under side and constructed of timber, should be supported on king-post trusses (see Figs. 37 and 38). The trusses are spaced 10 feet apart, and the scantlings required for various spans are as follows, viz. :—

Table of Scantlings for Roofs of Various Spans when Supported on King-post Trusses Spaced 10 Feet apart, and Ceiled on Under Side of Tie Beam.								
Span.	Tie Beam.	King Post.	Principal Rafters.	Struts.	Purlins.	Common Rafters.	Ridge.	Pole Plate.
	T.B.	K.P.	P.R.	S.	P.	C.R.	R.	P.P.
feet.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.
20	9 × 4	4 × 3½	4 × 4	4 × 2½	8 × 4¾	3½ × 2	7 × 1½	4 × 4
22	9½ × 4¼	4¼ × 3½	5 × 4¼	4¼ × 3	8 × 5	3¾ × 2	7 × 1½	4 × 4
24	10½ × 4½	4½ × 3½	5 × 4½	4½ × 3	8¼ × 5	4 × 2	7 × 1½	4 × 4
26	11½ × 4½	4½ × 4	5 × 4½	4½ × 3¼	8½ × 5	4¼ × 2	8 × 1½	4 × 4
28	11½ × 5	5 × 4	5½ × 5	5 × 3¼	8¾ × 5	4½ × 2	8 × 1½	4 × 4
30	12 × 5¼	5¼ × 4½	5¾ × 5¼	5¼ × 3½	9 × 5¼	4¾ × 2	9 × 1½	4 × 4

The reference letters at the head of each column in this and the following tables, relate to those shown on the various members of the corresponding roof trusses which have already been illustrated.

In the case of open roofs, where no ceiling is required, the scantling of the king-post trusses may be slightly reduced, as indicated in the following table, viz. :—

TABLE OF SCANTLINGS FOR ROOFS OF VARIOUS SPANS WHEN SUPPORTED ON KING-POST TRUSSES SPACED 10 FEET APART, AND NO CEILING IS REQUIRED.

Span.	Tie Beam.	King Post.	Principal Rafters.	Struts.	Purlins.	Common Rafters.	Ridge.	Pole-Plate.
	T.B.	K.P.	P.R.	S.	P.	C.R.	R.	P.P.
feet.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.
20	9 × 3½	3½ × 3	4½ × 3½	3½ × 2½	8 × 4¾	3½×2	7×1½	4×4
22	9 × 4	4 × 3½	5 × 4	4 × 3	8 × 5	3¾×2	7×1½	4×4
24	9 × 4¼	4¼ × 3½	5 × 4¼	4¼ × 3	8¼ × 5	4 ×2	7×1½	4×4
26	10 × 4½	4½ × 3¾	5 × 4½	4½ × 3	8½ × 5	4¼×2	8×1½	4×4
28	11 × 4¾	4¾ × 4	5½ × 4¾	4¾ × 3¼	8¾ × 5	4½×2	8×1½	4×4
30	11 × 5	5 × 4½	5¾ × 5	5 × 3½	9 × 5¼	4¾×2	9×1½	4×4

Timber-framed roofs for spans exceeding 30 feet should be supported on queen-post trusses spaced 10 feet apart. An open-framed roof of this class is shown in Fig. 26, having a continuous louvred ridge-ventilator above. The necessary scantlings for different spans are given in the accompanying table (p. 133), the timbers being sufficiently strong to carry a ceiling on the under side of the tie beam.

Where the trusses are not required to support a ceiling the following scantlings (p. 133) may be substituted for open queen-post roofs, viz. :—

TABLE OF SCANTLINGS FOR ROOFS OF VARIOUS SPANS WHEN SUPPORTED ON QUEEN-POST TRUSSES SPACED 10 FEET APART AND CEILED ON UNDER SIDE OF TIE-BEAM.

Span.	Tie Beam.	Queen Posts.	Principal Rafters.	Straining Beam.	Struts.	Purlins.	Common Rafters.	Ridge.	Pole Plate.
	T.B.	Q.P.	P.R.	S.B.	S.	P.	C.R.	R.	P.P.
feet.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.
32	$10\times4\frac{1}{2}$	$4\frac{1}{2}\times4$	$5\times4\frac{1}{2}$	$6\frac{3}{4}\times4\frac{1}{2}$	$4\frac{1}{2}\times2\frac{1}{2}$	$8\times4\frac{3}{4}$	$3\frac{1}{2}\times2$	$7\times1\frac{1}{2}$	4×4
34	$10\times4\frac{3}{4}$	$4\frac{3}{4}\times4$	$5\frac{1}{2}\times4\frac{3}{4}$	$7\times4\frac{3}{4}$	$4\frac{3}{4}\times3$	8×5	$3\frac{3}{4}\times2$	$7\times1\frac{1}{2}$	4×4
36	$11\times4\frac{3}{4}$	$4\frac{3}{4}\times4$	$6\times4\frac{3}{4}$	$7\frac{1}{2}\times4\frac{3}{4}$	$4\frac{3}{4}\times3$	$8\frac{1}{4}\times5$	4×2	$8\times1\frac{1}{2}$	4×4
38	11×5	5×4	6×5	8×5	5×3	$8\frac{1}{2}\times5$	4×2	$8\times1\frac{1}{2}$	4×4
40	$11\times5\frac{1}{2}$	$5\frac{1}{2}\times4\frac{1}{4}$	$6\frac{1}{4}\times5\frac{1}{2}$	$8\frac{1}{2}\times5\frac{1}{2}$	$5\frac{1}{2}\times3\frac{1}{4}$	$8\frac{3}{4}\times5$	$4\frac{1}{4}\times2$	$9\times1\frac{1}{2}$	4×4
42	$12\times5\frac{1}{2}$	$5\frac{1}{2}\times4\frac{1}{2}$	$6\frac{1}{2}\times5\frac{1}{2}$	$9\times5\frac{1}{2}$	$5\frac{1}{2}\times3\frac{1}{2}$	9×5	$4\frac{1}{2}\times2$	$9\times1\frac{1}{2}$	4×4

TABLE OF SCANTLINGS FOR ROOFS OF VARIOUS SPANS WHEN SUPPORTED ON QUEEN-POST TRUSSES SPACED 10 FEET APART AND NO CEILING IS REQUIRED.

Span.	Tie Beam.	Queen Posts.	Principal Rafters.	Straining Beam.	Struts.	Purlins.	Common Rafters.	Ridge.	Pole Plate.
	T.B.	Q.P.	P.R.	S.B.	S.	P.	C.R.	R.	P.P.
feet.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.
32	$9\times4\frac{1}{2}$	$4\frac{1}{2}\times3$	$5\times4\frac{1}{2}$	$6\frac{1}{2}\times4\frac{1}{2}$	$4\frac{1}{2}\times2\frac{1}{2}$	$8\times4\frac{3}{4}$	$3\frac{1}{2}\times2$	$7\times1\frac{1}{2}$	4×4
34	$9\times4\frac{3}{4}$	$4\frac{3}{4}\times3\frac{1}{2}$	$5\frac{1}{4}\times4\frac{3}{4}$	$6\frac{3}{4}\times4\frac{3}{4}$	$4\frac{3}{4}\times3$	8×5	$3\frac{3}{4}\times2$	$7\times1\frac{1}{2}$	4×4
36	$9\frac{1}{2}\times4\frac{3}{4}$	$4\frac{3}{4}\times3\frac{3}{4}$	$5\frac{3}{4}\times4\frac{3}{4}$	$7\frac{1}{4}\times4\frac{3}{4}$	$4\frac{3}{4}\times3$	$8\frac{1}{4}\times5$	4×2	$8\times1\frac{1}{2}$	4×4
38	$9\frac{1}{2}\times5$	$5\times3\frac{3}{4}$	6×5	8×5	5×3	$8\frac{1}{2}\times5$	4×2	$8\times1\frac{1}{2}$	4×4
40	$10\times5\frac{1}{4}$	$5\frac{1}{4}\times4$	$6\frac{1}{4}\times5\frac{1}{4}$	$8\frac{1}{2}\times5\frac{1}{4}$	$5\frac{1}{4}\times3\frac{1}{4}$	$8\frac{3}{4}\times5$	$4\frac{1}{4}\times2$	$9\times1\frac{1}{2}$	4×4
42	$10\frac{1}{2}\times5\frac{1}{2}$	$5\frac{1}{2}\times4\frac{1}{4}$	$6\frac{3}{4}\times5\frac{1}{2}$	$8\frac{3}{4}\times5\frac{1}{2}$	$5\frac{1}{2}\times3\frac{1}{2}$	9×5	$4\frac{1}{2}\times2$	$9\times1\frac{1}{2}$	4×4

In the construction of open roofs for spans up to 22 feet, iron trusses similar to that shown in Fig. 29 may be used. The principal rafters are of ⊤ section, and the tie rods of round bar iron. The roof trusses should be spaced about 8 feet apart.

The following table gives the sizes required for the different members of each truss for varying spans, viz. :—

TABLE SHOWING SIZES REQUIRED FOR IRON ROOF TRUSSES SPACED 8 FEET APART.

Span.	Principal Rafters.	Struts.	King Rod.	Tie Rods.
feet.	inches.	inches.	Diameter, inches.	Diameter, inches.
18	$2\frac{1}{2} \times 2\frac{1}{2} \times 0\frac{3}{8}$	$2\frac{1}{4} \times 2\frac{1}{4} \times 0\frac{1}{4}$	$\frac{3}{4}$	$\frac{7}{8}$
20	$3 \times 3 \times 0\frac{3}{8}$	$2\frac{1}{4} \times 2\frac{1}{4} \times 0\frac{1}{4}$	$\frac{3}{4}$	$\frac{7}{8}$
22	$3 \times 3 \times 0\frac{3}{8}$	$2\frac{1}{4} \times 2\frac{1}{4} \times 0\frac{1}{4}$	$\frac{3}{4}$	$\frac{7}{8}$

An iron roof truss suitable for stables, from 25 feet to 35 feet span, is shown in Fig. 118. The principal rafters are

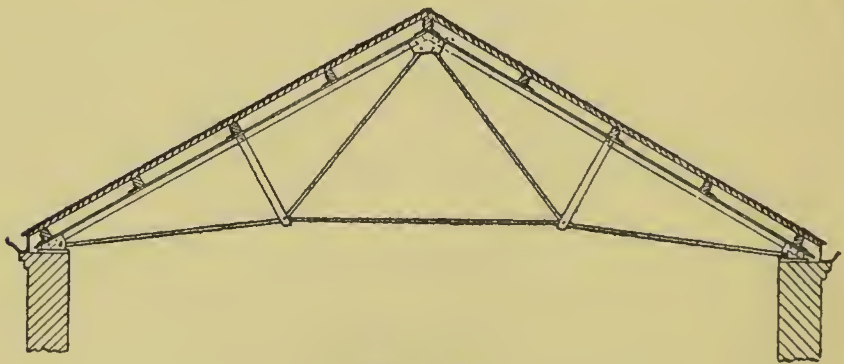


FIG. 118.

of ⊤ iron, and the tie rods of round bar iron. The struts may be of wrought or cast iron, but wrought-iron flat bars are now chiefly used.

The sizes required for rafters and tie rods of this form of truss are as follows, viz. :—

TABLE SHOWING SIZES REQUIRED FOR IRON ROOF TRUSSES SPACED 8 FEET APART.

Span.	Principal Rafters.	Tie Rods.	
feet.	inches.	Diameter, inches.	Diameter, inches.
25	$3 \times 3 \times 0\frac{3}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
30	$3\frac{1}{2} \times 3\frac{1}{2} \times 0\frac{3}{8}$	$\frac{7}{8}$	1
35	$3\frac{1}{2} \times 3\frac{1}{2} \times 0\frac{1}{2}$	1	$1\frac{1}{8}$

Occasionally composite roof trusses are used, in which the principal rafters are of timber, the remaining portion of the trusses being of iron. Such a method of construction possesses some advantages under certain circumstances; but it is not now usually adopted.

The effective "pitch" or slope that must be given to the roof largely depends on the material with which it is covered, but in all cases it should be sufficient to throw off the rain rapidly. For roofs covered with slates, the height of the roof should be from $\frac{1}{4}$ to $\frac{1}{3}$ the span, which gives a slope of $26\frac{1}{2}°$ to 33°. Where tiles are used, the height of the roof should be from $\frac{1}{3}$ to $\frac{1}{2}$ the span, equivalent to an inclination of 33° to 45° with the horizontal plane.

The roof covering must be arranged not only to keep out the rain but also to assist in the maintenance of an equable temperature within the building, so that the interior may be cool in summer and warm in winter. For this purpose the roof should be entirely covered with boarding before the slates or tiles are laid. To obtain the best results a layer of asphalted felt or other similar non-conducting material should be inserted between the boarding and the tiles or slates, the latter being then secured to longitudinal laths or battens

nailed on the felt. The air space between the felt and the tiles or slates acts as a further non-conductor and preserves the felt from premature decay.

For the cheapest class of buildings, as for farmsteads, &c., galvanised corrugated sheet iron is largely used as a roof covering. This is generally laid directly on the rafters or purlins without any intervening non-conducting material. Such roofs, however, render the interior undesirably hot in summer and cold in winter. They are only suitable for stables designed to shelter horses and stock of the hardiest description.

CHAPTER XIV.

DOORS.

DOORS:—Narrow openings objectionable—Stable and cow-house doors—Self-acting back fasteners—Door frames for stables—Sliding door fitted with bottom rollers—Door Rollers—Sliding door hung on top rollers—Harness-room doors—Coach-house doors—Gates for stable-yards.

STABLE doors should in all cases be sufficiently high and wide to allow the horses to enter and leave the stable without the slightest inconvenience when fully harnessed. In passing through narrow doorways horses are liable to damage either themselves or their harness by rubbing and knocking against the jambs of the opening. The doors may be hung with hinges or arranged to slide on rollers. When hung with hinges, they should invariably be designed to open outwards, so as to fall back quite flat against the wall. A small fan-light about 1 foot 6 inches high should also be provided over each door.

Figs. 119, 120, 121 and 122 show the plan, internal elevation, external elevation, and section of a door and frame well suited for ordinary stables and cow-houses. The door is 8 feet high, 4 feet 6 inches wide, and made in two heights, the lower portion being 3 feet 6 inches high. The thickness is $2\frac{1}{4}$ inches, the whole being wrought both sides, framed, braced, and filled in with 1-inch wrought, ploughed, tongued, and beaded battens, put together with white lead. The top edge of the lower portion is weathered or bevelled outwards, and bound with $2\frac{1}{4}$-inch by $\frac{1}{8}$-inch strap iron, holed and countersunk, turned over 3 inches at each end, and secured with $1\frac{1}{2}$-inch screws. The bottom edge of the upper portion

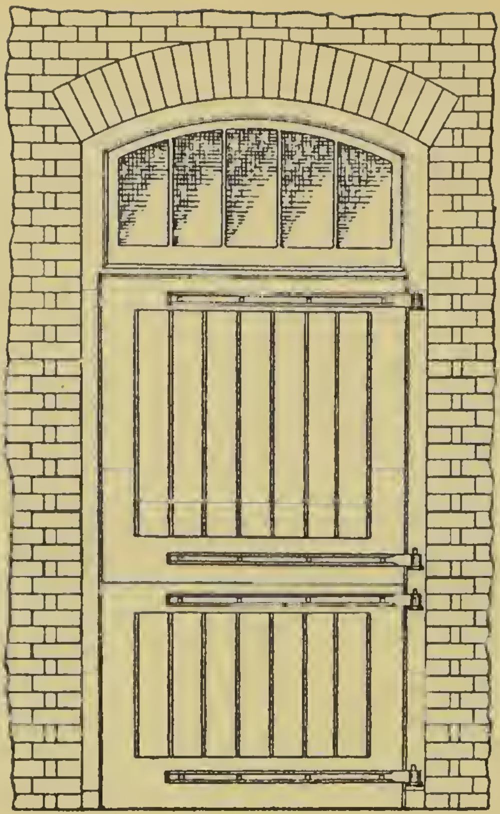


Fig. 120.

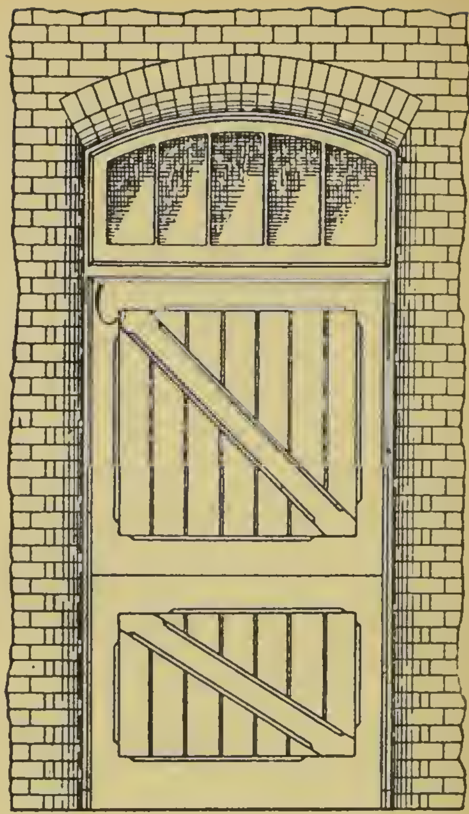


Fig. 121.

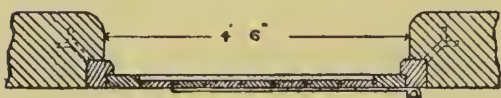


Fig. 119.

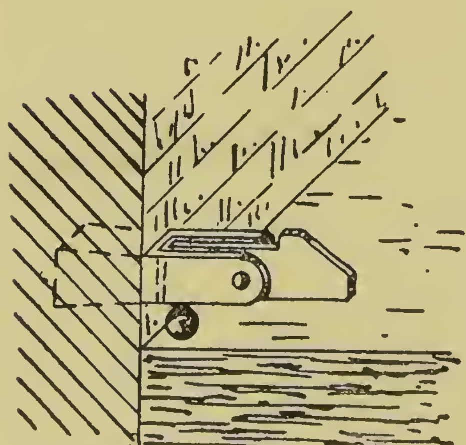


Fig. 123.

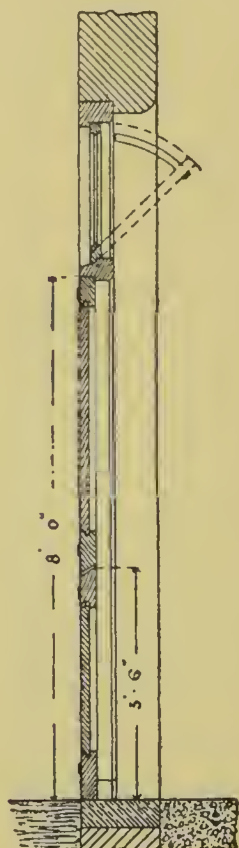


Fig. 122.

of the door is bevelled upwards and inwards, so as to form a close weather-tight joint at this point and prevent the rain driving in. The upper and lower portions are each hung with one pair of 30-inch hook-and-eye strap hinges. The lower portion is secured with one or two 10-inch bright-rod bolts, and the upper portion with a flush ring stable latch and strong lock. When open, the door is held back close to the wall by means of a self-acting back fastener similar to that shown in Fig. 123.

The door frame is 5 inches by 4 inches in section, wrought, framed, rebated, and chamfered; and secured with four wrought-iron holdfasts (two on each side) built into the wall. The holdfasts have one end turned up, and are secured to the back of the frame with strong screws, the other end being split and forked, as shown by the dotted lines in Fig. 119. The ends of the door frame are fitted with cast-iron shoes about 3 inches high, $\frac{3}{8}$-inch thick, with $1\frac{1}{4}$ inch stub tenon let into the stone sill and bedded to the frame in white lead.

The upper part of the door frame is formed with a 5-inch by $3\frac{1}{2}$-inch wrought, weathered, double rebated, and chamfered transom, having a 2-inch bevel-bar fanlight above. The fanlight is rebated, weather-grooved, and hinged at the bottom edge, the sash being opened and closed by means of a quadrant stay bar provided with a pulley, sash line, and belaying pin. As already stated, the angles of all openings should be well rounded, and no projections of any description permitted.

For stables accommodating large numbers of heavy draught horses of the class required for breweries, carriers, &c., it is better to have the door openings not less than 8 feet by 5 feet, and provided with a sliding door, as shown in Figs. 124, 125, and 126, with or without fanlight over. The door is $2\frac{1}{2}$ inches thick, wrought, framed, braced, and filled-in with 1-inch ploughed, tongued, and beaded battens, put together with white lead, and fitted with one pair of 5-inch diameter bottom rollers mortised into the door and running on a wrought-iron rail. A wrought-iron guide bar is screwed to the back of the transom, the upper edge of the door being prepared to receive

the corresponding grooved rail required in connection with the form of guide bar shown.

In the ordinary type of door roller, it is found that the axle wears very unevenly after continued use, causing in-

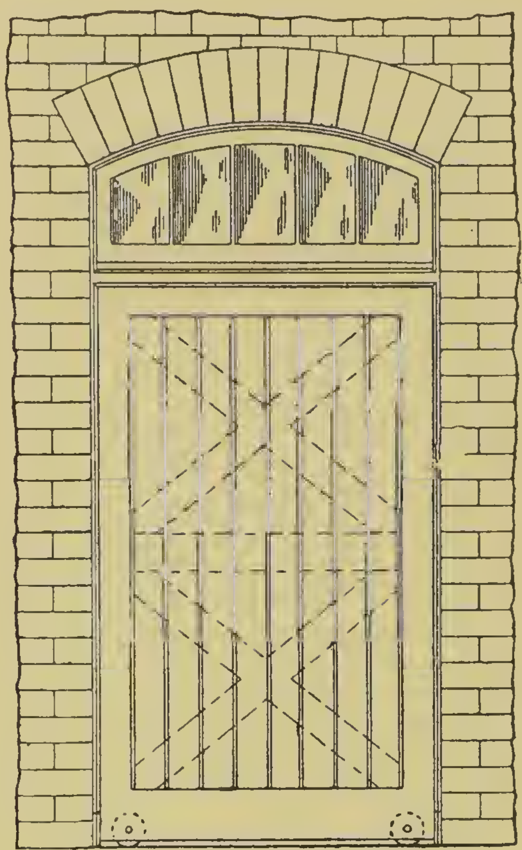


FIG. 125.

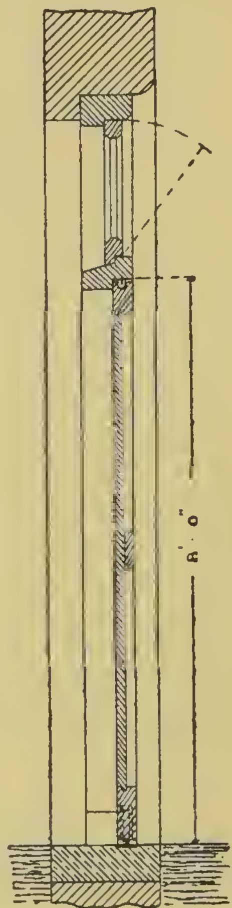


FIG. 126.

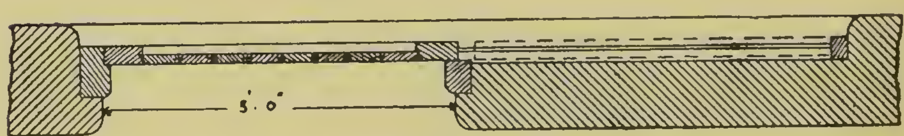


FIG. 124.

creased friction and greater difficulty when opening and closing the door. Fig. 127 shows an improved form of roller, in which the axle is allowed to roll freely in a slot, thus minimising the friction, and permitting the door to be opened and closed with ease.

Another method of fixing sliding doors is to suspend them on rollers from an iron rail at the top of the door opening, as shown in Fig. 128. The doors are provided with a guide rail and guides at the bottom.

A serviceable door for harness rooms is shown in Figs. 129 and 130. It is 6 feet 6 inches high, 3 feet wide, and

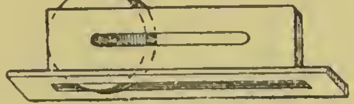


FIG. 127.

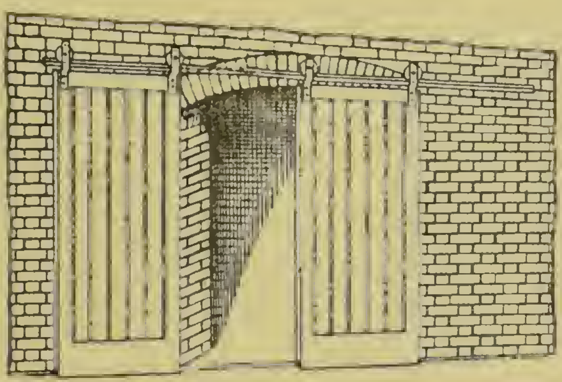


FIG. 128.

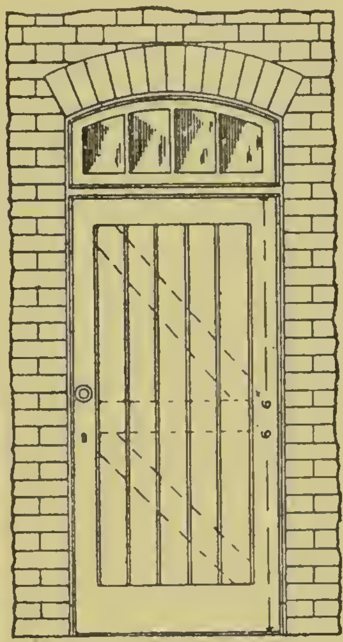


FIG. 130.

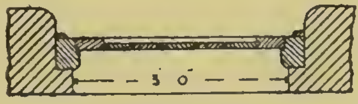


FIG. 129.

$2\frac{1}{4}$ inches thick, wrought, framed, and braced, filled in with 1-inch grooved, tongued, and beaded battens, and hung to 5-inch by 4-inch fir proper door frame with one and a half pairs of $4\frac{1}{2}$-inch butt hinges. The door is secured with a strong Norfolk latch and dead-shot lock, the frame being fixed to the walls with four wrought-iron holdfasts, and fitted with cast-iron shoes. A fanlight similar to that already described for stable doors is also provided.

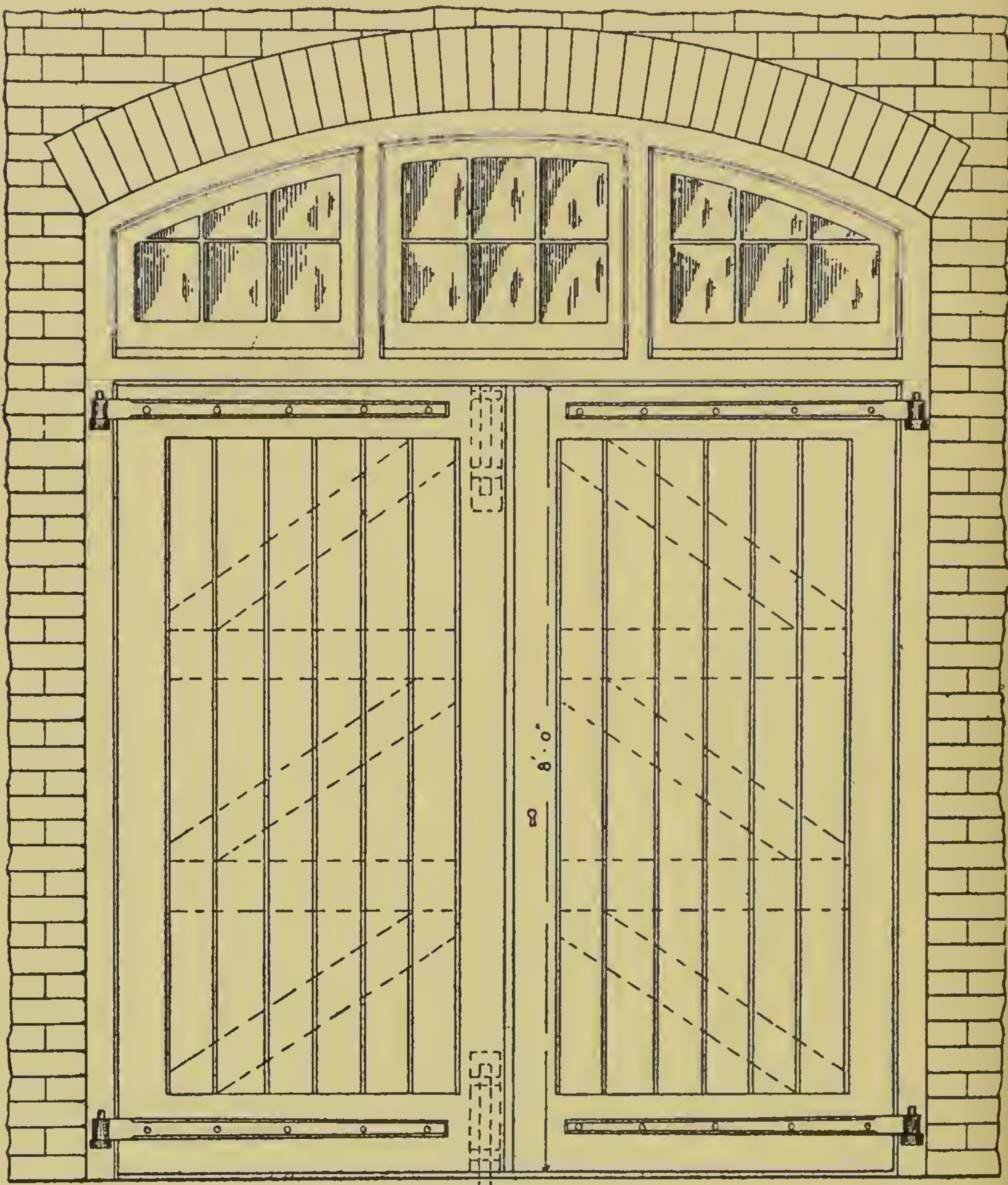


FIG. 132.

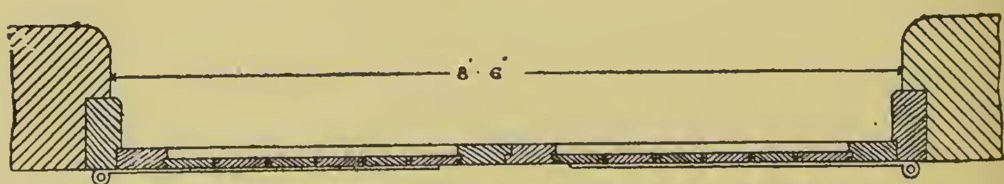


FIG. 131.

The usual construction of doors for coach-houses and stores is shown in Figs. 131 and 132, the size of the opening

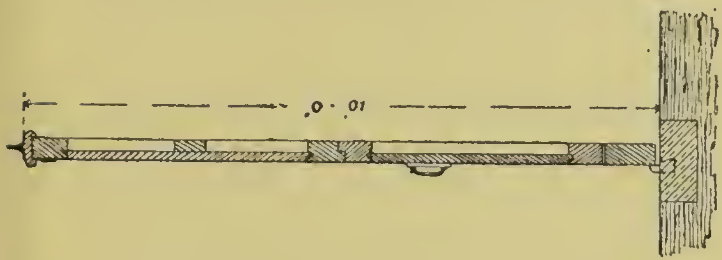


Fig. 135.

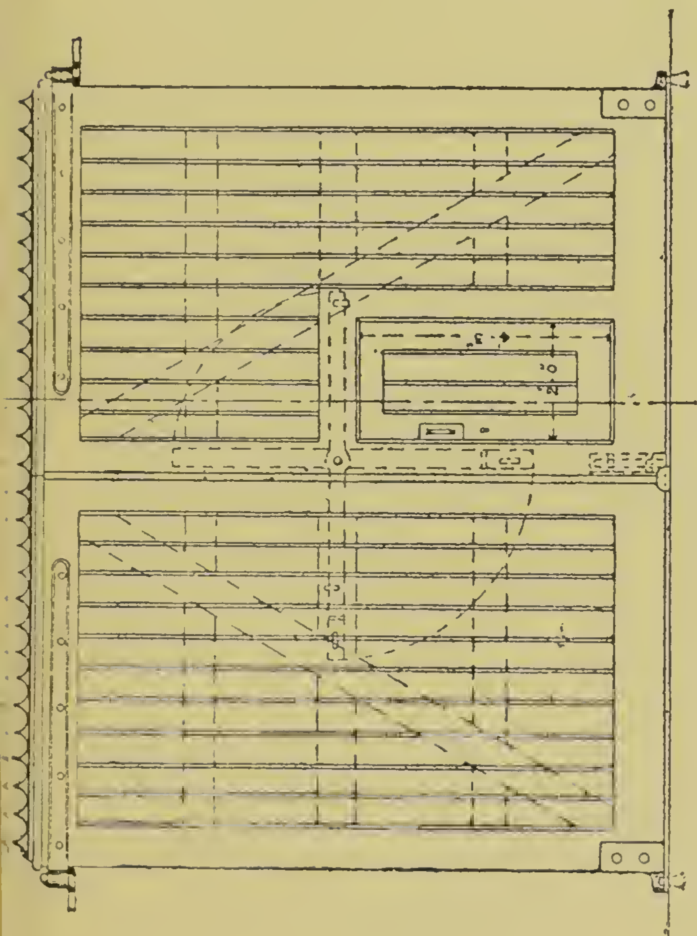


Fig. 134.

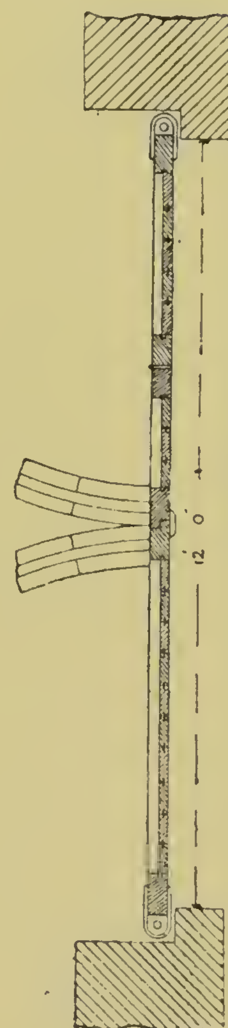


Fig. 133.

being 8 feet 6 inches wide and 8 feet high. The doors are $2\frac{1}{2}$ inches thick, wrought, framed, and braced, filled in with

$1\frac{1}{4}$-inch grooved, tongued, and beaded battens, and hung folding with wrought-iron strap hinges to a 9-inch by 6-inch fir proper door frame. Instead of being hung with hinges, the gates may be arranged to slide on top or bottom rollers.

Figs. 133, 134, and 135 are the plan, elevation, and section of a pair of gates suitable for stable yards, &c. The gates are 3 inches thick, wrought, framed, ledged, and braced ; filled in with $1\frac{1}{4}$-inch grooved, tongued, and beaded battens, hung folding, and provided with a small wicket gate. The upper hinges are strong wrought-iron hook and eye hinges, the hooks being securely leaded into a stone block. The lower hinges turn on stout gun-metal pivots leaded into a stone base. A 5-inch by 3-inch oak, wrought, sunk, and rounded capping with wrought-iron spiked ridge is fixed on the top of the gates, whilst the bottom edge is provided with gun-metal friction rollers running on $2\frac{1}{2}$-inch by $\frac{1}{2}$-inch wrought-iron racers let into a stone curb and run with lead. The gates are secured with a strong barrel bolt, together with a wrought-iron swing bar with hooks riveted on plates, and fitted at one end with hasp, staple, and padlock. The wicket gate is formed of $2\frac{1}{2}$-inch deal, wrought, framed, rebated, and beaded ; filled in with 1-inch deal battens, grooved, tongued, and beaded ; hung with one pair of $4\frac{1}{2}$-inch butt hinges, and secured with a Norfolk thumb latch and dead-shot lock.

CHAPTER XV.

INTERNAL WALL SURFACES.

INTERNAL WALL SURFACES:—Lime-whiting or colouring to walls—Portland cement dado for stables—Glazed bricks—Materials generally used for lining walls—Iron mouldings and cappings—Wall tiles of glaring colours to be avoided—Glass tiles—Wood linings—Various methods adopted for lining stalls, loose boxes, and gangways—Boarding under mangers—Concrete ramps or slopes.

THE method of finishing the interiors of stables depends in a great measure on the class of building to which it is to be applied. For stables of a plain and inexpensive character, such as are required for farmsteads, tramway companies, general carriers, &c., the face of the brickwork is generally left exposed, the joints being flat-pointed and the surface lime-whited or colour-washed.

A good appearance is obtainable at a slightly increased cost by rendering the walls with Portland cement and sand to a height of 6 or 7 feet, the remaining portion being left exposed, or plastered in the ordinary manner. The upper part of the wall should then be colour-washed or distempered, the cement dado being painted a darker shade of the same colour. Quiet and subdued tones of colour should be selected, such as light blue, pale green, French grey, and others of a similar character.

The walls of better class stables are finished in a much more expensive manner, the general appearance being thereby greatly improved. The inner face of the walls may be built with glazed bricks of different colours, and jointed in cement. The result from a sanitary point of view is all that can be desired, as a thoroughly non-absorbent surface is

obtained which is easily kept clean by simply washing with water. There are, however, some objections to this mode of treatment being carried out in its entirety, for the lower part of the glazed brickwork is liable to be damaged by the horses and attendants.

The materials usually employed for lining the walls of stables are wood, glazed tiles, slate, marble, enamelled iron, and cement. For general purposes a satisfactory finish will be obtained by lining the whole of the walls with wood, from the floor to a height corresponding with that of the

Fig. 136.

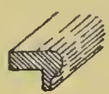
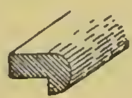


Fig. 137.



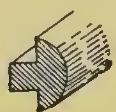


Fig. 138.

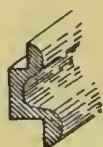


Fig. 139.

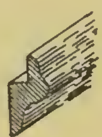


Fig. 140.

manger level (about 3 feet 6 inches high). By thus boarding the lower portions of the walls the risk of nervous or restive animals damaging themselves is minimised. The walls of the loose boxes, and also that portion immediately over the manger in the stalls should be then lined with glazed tiles from the manger level as far as the top rail of the loose box or stall division. Marble slabs, plain or enamelled slate slabs, or enamelled iron plates may be substituted for the glazed tiles if desired. The mouldings and cappings for the wall boarding and tiles should be of iron, so that they may not be disfigured by the biting and gnawing of the horses. Sections of iron mouldings and cappings as generally used for this purpose are shown in Figs. 136 to

140. The remaining portion of the walls should be plastered and distempered in some suitable shade of colour.

In the selection of glazed wall tiles care should be taken to avoid all glaring colours, as the reflected rays of light from such surfaces are injurious to the horses' eyesight. For this reason white glazed tiles should not be used except in badly lighted stables. The most suitable colours are French grey, olive-green, turquoise, pea-green, &c. They may be obtained either square, hexagonal, or octagonal in shape, and are frequently fixed with an ornamental border around them.

Wall tiles of opaque glass with a dull roughened surface are now manufactured, and may be used instead of the ordinary glazed tiles. They are quite impervious to moisture, and have the advantage of not presenting a smooth polished surface like porcelain tiles. They are, however, very thin and brittle, and require to be carefully bedded and pointed in cement.

The woods in most general use for lining the walls are red deal, pitch pine, oak, and teak. For first-rate work teak is recommended; but where oak or teak cannot be used on the ground of expense, then pitch pine is to be preferred. The surface of the woodwork should be well sized, and afterwards varnished with two coats of best copal varnish.

Fig. 141 is the sketch of a stable interior showing various alternative arrangements which may be adopted in finishing the walls of loose boxes, stalls, and gangways. Loose box No. 1 is shown lined with wood to the full height of the division. To improve the general appearance a middle rail is inserted at the manger level, and the upper part framed and panelled, the lower portion being filled in with match-boarding. It is, however, much more satisfactory to line the wall from the manger level to the top rail of the division with a non-absorbent material like glazed tiles, slate, &c., than with wood, as the latter material becomes impregnated with the moisture and organic matters given off by the horse during respiration.

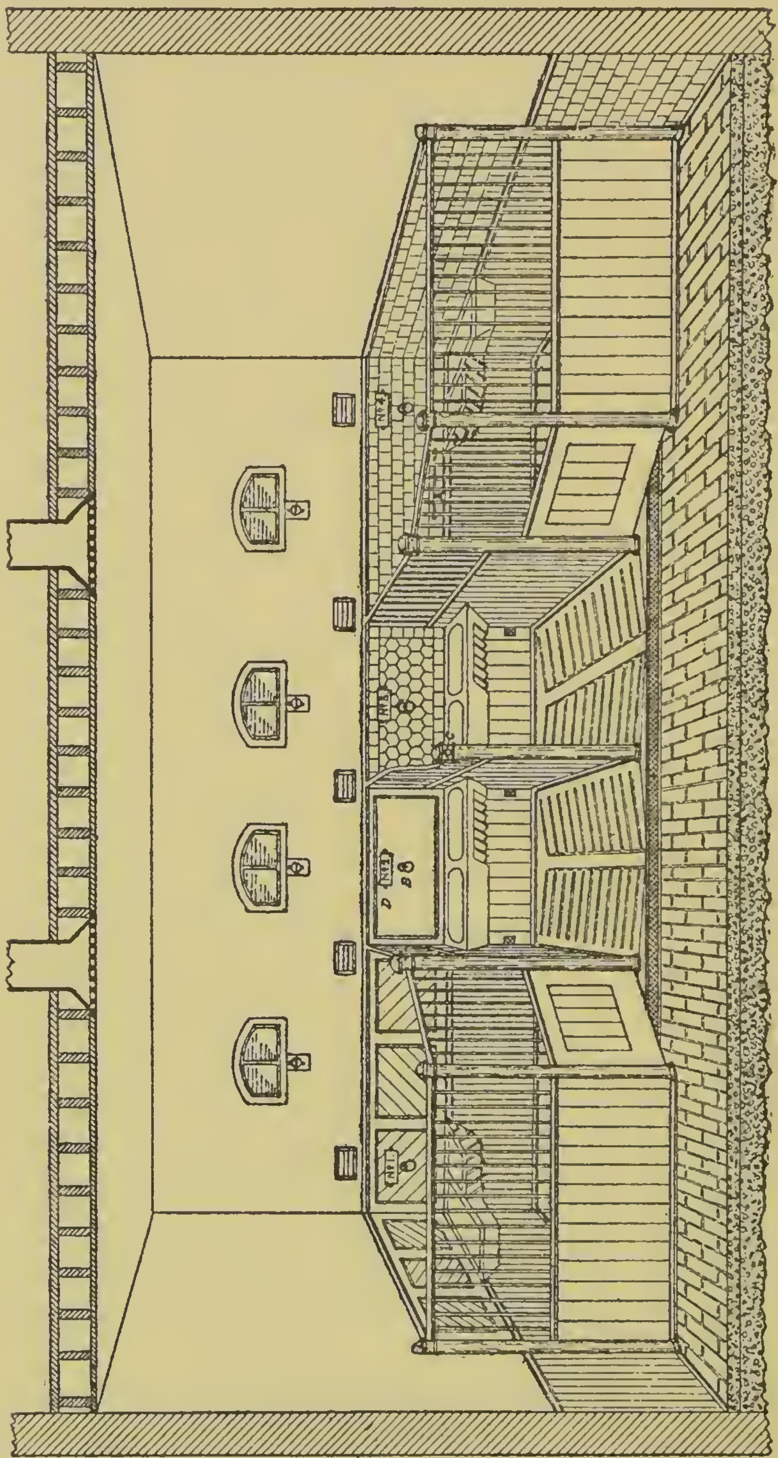


Fig. 141.

Stall No. 2 is provided with a slate slab fixed directly over the manger, thus affording an impermeable surface near the horse's head which can be easily kept clean, and does not absorb the moisture or other impurities from the animal's breath.

The portion of wall between the manger and top rail of the divisions to stall No. 3 is lined with hexagonal glazed tiles. In buildings of an expensive character these are

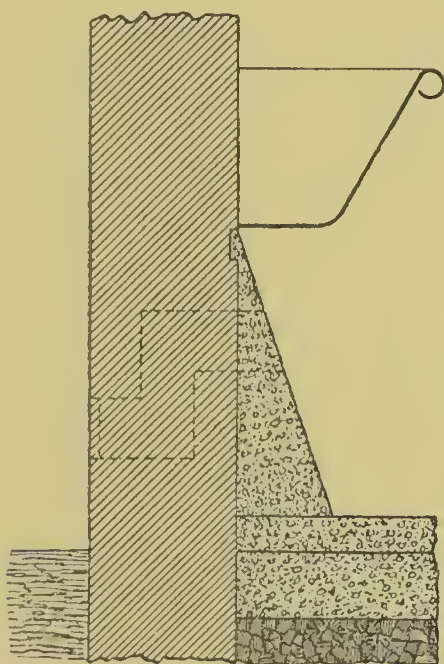


FIG. 142.

arranged in the form of a panel with a border of ornamental tiles.

The walls of loose box No. 4 are finished with wall boarding to the height of the manger, whilst the space between the manger level and the top rail of the division is lined with square glazed wall tiles. A good appearance is obtained by such a mode of treatment.

The walls of the passages or gangways are either finished with boarding, as shown on the end wall adjoining loose

box No. 1 (Fig 141), or lined with glazed tiles, as indicated at the gangway near loose box No. 4. The former method is preferred, as the wall tiles near the floor are liable to be greatly damaged by the constant passing of horses and stablemen.

The small portion of wall under the mangers of the stalls is sometimes rendered smooth with Portland cement instead of being lined with wood, the finished surface being afterwards painted or colour-washed. Where ordinary manger fittings are used, a horse when lying down will occasionally be found resting with his head quite under the manger, and in such a position that on suddenly rising he may be seriously hurt by coming in contact with the under side of the manger. To prevent accidents of this description the space is frequently boarded-in flush with the front of the fittings. An alternative method consists in forming a concrete ramp or slope under the manger, as shown in Fig. 142, the face of the concrete being rendered perfectly smooth with cement. In the construction of military stables, concrete ramps similar to that just mentioned are largely used.

CHAPTER XVI.

STABLE FITTINGS.

STABLE FITTINGS:—Wooden mangers and hay-racks objectionable—Advantages of iron fittings—Loose boxes—Stall divisions—Ventilating ramps—Solid panels—Ventilating sills—Sliding barriers—Shifting pieces—Convertible loose boxes—Safety latches—Hanging bails—Overhead and underhead hay-racks—Hay-racks arranged on a level with the mangers—Height of mangers—Wrought-iron manger guard—Safety mangers—Fittings for preventing crib biting—Tying apparatus—Head-stall fastening—Pillar-chains—Name plates.

OF late years the general construction and arrangement of stable fittings have received great attention at the hands of manufacturers, so that at the present time an almost embarrassing assortment of well-designed, serviceable, and convenient appliances adapted for various purposes may be obtained at a comparatively small cost. Formerly the fittings of stables were almost entirely constructed of wood, and the old pattern wooden manger, with sloping overhead hay-rack, is familiar to all. In out-of-way places they had the recommendation of being easily made and repaired by the average carpenter; but, on the other hand, they were being continually damaged from the biting and gnawing of horses.

The use of an absorbent material such as wood has also been found to be a fertile source of spreading infectious diseases—particularly in large town stables—and many cases of farcy, glanders, &c., have been traced to this cause. Notwithstanding such a serious drawback, wooden fittings are still extensively used in country districts, and almost

invariably in farm buildings of an ordinary character, owing to their relative cheapness.

For modern stable fitments, wrought or cast iron has now taken the place of wood to a very large extent, as it possesses distinct sanitary advantages over the latter material. It is non-absorbent, cleanly in use, strong, cannot be destroyed by the horses' teeth, presents a good appearance, and is readily washed and cleaned.

In the consideration of the general internal arrangement of stables, it is usually found necessary for the animals' welfare and comfort that they should be separated from each other—more or less completely—so as to prevent them disturbing or injuring their immediate neighbours. Where entire separation is required, a series of loose boxes is constructed as shown in Figs. 45 and 46. Stables which are divided into loose boxes form the most comfortable and luxurious arrangement practicable. Such a method is frequently adopted for housing hunters and racers; but for ordinary purposes it is quite sufficient if the horses are separated from each other by a series of stall partitions sufficiently high and long to prevent the possibility of one horse biting or kicking another. The distance between the partitions should be sufficient to permit each horse to lie down and get up without being in any way cramped for space. They should be not less than 6 feet wide, whilst for large horses 6 feet 6 inches, or even 7 feet, may be allowed with advantage.

As already mentioned, the stall divisions in farm stables are commonly constructed of wood, as shown in Fig. 143. The heel post is usually of oak, 6 inches by 6 inches in section, and about 5 feet high, having two or three $5\frac{1}{2}$-inch by $1\frac{1}{2}$-inch deal rails framed into it, the other ends of the rails being pinned into the wall. Deal stall-boarding $1\frac{1}{2}$ inches thick is then nailed to one side of the rails.

On the grounds of cleanliness, neatness, and general efficiency, it is far better to substitute cast or wrought iron

for the wooden heel post and rails, as the extra cost thereby involved in the construction of an ordinary sized stable is inconsiderable. Fig. 144 shows a serviceable stall division

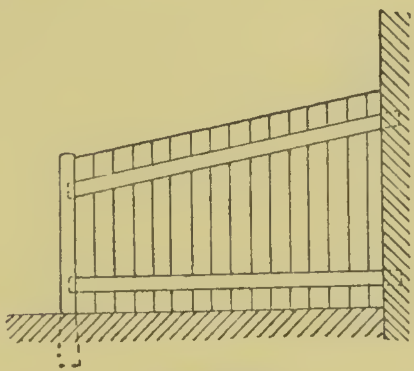


Fig. 143.

of this character (filled in with $1\frac{1}{2}$-inch boarding), which is largely used in army stables. The top rail is curved or "ramped," and fitted with a wall socket at the upper end, so that the ramp may be taken out at any time, as for instance, when it is required to replace broken or defective boards. Instead of a curved rail, a straight top rail may be used if preferred.

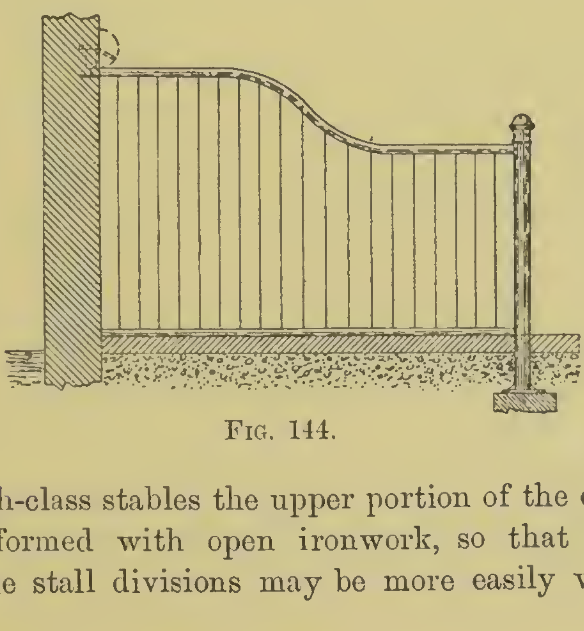


Fig. 144.

For high-class stables the upper portion of the division is generally formed with open ironwork, so that the space between the stall divisions may be more easily ventilated.

Examples of this arrangement are seen in Figs. 23 and 24, the space between the middle and top rail being filled in with iron bars. Fig. 145 is a transverse section through a stall division fitted with an iron sill, middle, and top rail. The space between the sill and middle rail is filled in with boarding (preferably teak or oak), whilst a ventilating grating is inserted between the middle and top rails. In some instances a solid panel is introduced at the head of the ventilating division, as indicated in Figs. 23 and 147, so that the horses may not see each other whilst feeding. Instead of plain straight bars, numerous ornamental patterns for ventilating ramps may be obtained.

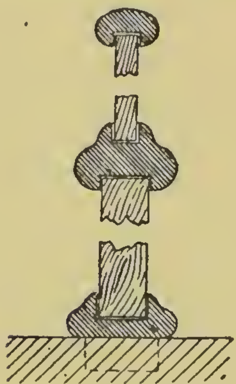


FIG. 145.

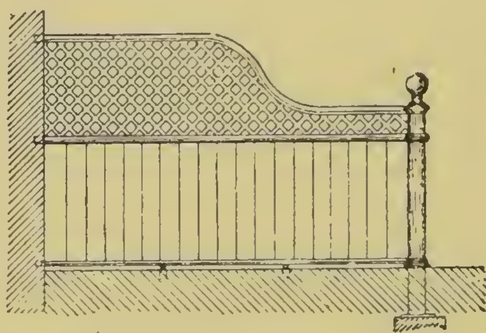


FIG. 146.

In addition to the upper portion of the division being formed with an open or ventilating grating, other designs are made, which are fitted with a ventilating sill or a narrow ventilating panel near the floor. Fig. 146 is an illustration of a stall division fitted with a ventilating sill. It will be observed that the bottom rail or sill is slightly raised, leaving an open space between it and the floor, so as to permit a certain amount of circulation of the air taking place at the ground level.

An improved form of ventilating sill has been introduced, in which the sill is arranged with a narrow perforated panel for ventilation purposes. An iron ventilating head-plate is

also fitted between the sill and middle rail at the head of the stall division, the portion under the manger being perforated, thus ensuring a better circulation of air throughout the stable, whilst at the same time it does not interfere with the complete separation of the stalls from one another. In army stables similar results are obtained by fixing a wrought-iron grating under the manger at the head of each stall division, as indicated in Figs. 26 and 38.

For the better protection of valuable horses when housed in stalls, the divisions are frequently fitted with "sliding barriers," as shown in Fig. 147. The middle rail is hollow, and forms a case or sheath in which slides a stout iron bar.

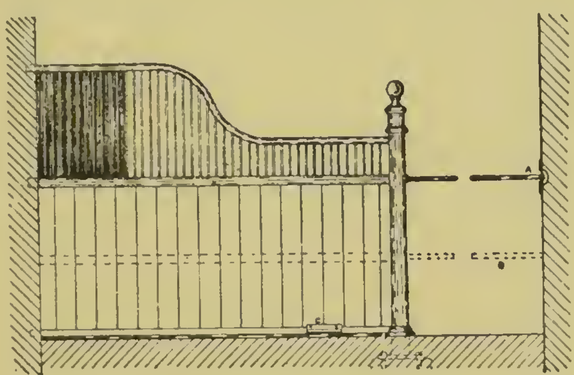


FIG. 147.

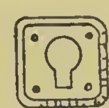


FIG. 148.

When necessary this is drawn out (as at A), and the end made secure in a slotted recess formed in the wall. By this means each horse is practically confined to its own stall, and should it become loose and restive at any time, is incapable of interfering with the other occupants of the stable. Fig. 148 is an elevation of the slotted wall plate which receives the end of the barrier. For additional security an intermediate rail and sliding barrier is sometimes provided, as indicated at B, Fig. 147. The sill is shown with a "shifting piece" at C, so as to allow the stall-boarding to be renewed when damaged. Shifting pieces are also provided to the intermediate rails when required.

The height of the top rail of a stall division is generally about 5 feet above the floor level at the heel post, and varying from 6 feet 9 inches to 7 feet 6 inches at the head. The middle rail of a stall division with ventilating ramp is from 4 feet to 4 feet 8 inches above the floor.

Sometimes it is found convenient to arrange the end stalls of stables in such a way that two stalls may be converted

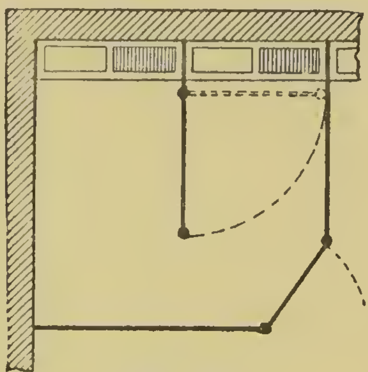


Fig. 149.

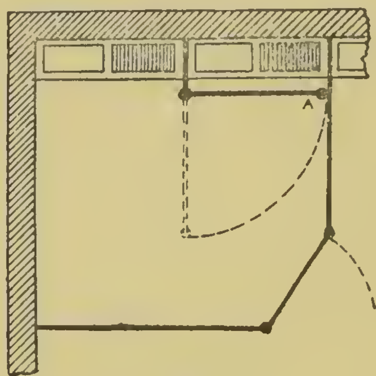


Fig. 150.

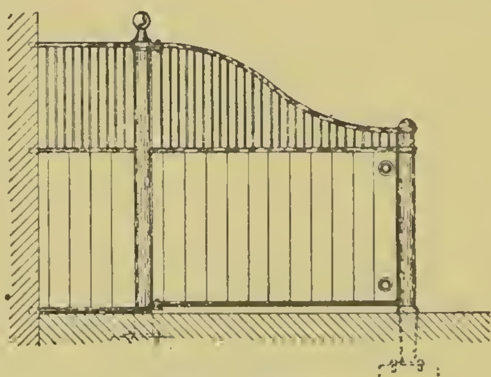


Fig. 151.

into a comfortable loose box. Figs. 149 and 150 show the plans of such an arrangement, in which the same space may be utilised for providing two stalls or a loose box respectively. Fig. 151 is an elevation of the intermediate stall division, as made by the General Iron Foundry Co., Ltd., and other well known makers of stable fittings. It is provided with an additional post near the head, to which the remainder of the division is hung. To convert the two stalls into a loose

box, the intermediate stall division is swung back as at A in Fig. 150, thus entirely shutting off one portion of the manger fittings, as they would not be required when the space is used as a loose box. The heel post is then lifted out of its ground socket, and the surface of the floor made level at this place with an iron cover. All the working parts of the movable heel post and hinged division must be of brass, so that they may not be rendered unserviceable by rust should they be left unused for any length of time.

The doors of loose boxes may be hung with hinges, or arranged to slide on top or bottom rollers. The hinges, fastenings, handles, and other fittings should be designed so that they do not project beyond the face of the door—whether it be open or closed—as such projections might cause serious injury to a valuable horse. Several excellent forms of safety latch which are specially constructed for the doors of stables and loose boxes are now obtainable. These are so arranged that the catch or tongue of the latch falls back, and is quite flush with the door and frame when open, but which automatically projects and secures the door when it is closed. The latches should be of the mortise pattern, and provided with flush drop handles.

Where large numbers of horses require to be accommodated, and the strictest economy—both of space and outlay—must at the same time be exercised, as in tramway, omnibus, general carriers, and army stables, the separation of the horses is effected by means of "hanging bails." These regulate the amount of space to be occupied by each animal; but they are sometimes the cause of much injury to restless or vicious horses, for in kicking and plunging they frequently get "cast" or entangled with the bail. For this reason the bails should be so hung that they can be easily loosed, and the horse released from its awkward and dangerous position.

With the use of bails, less breadth may be allowed than would otherwise be required for stall partitions. Fig. 152 is

the elevation of a hanging bail as sometimes used in large stables. Each bail consists of two stout elm planks, 12 to 14 inches wide, 2 inches thick, and 9 or 10 feet long. The upper plank is suspended by means of wrought-iron chains and hooks, the two planks being connected with stout hinged joints. In some cases the lower plank is omitted.

Several forms of "safety" attachment have been designed for the purpose of allowing the bail to be readily unhooked in an emergency. Where the arrangement shown in Fig. 152 is adopted, the end of the bail is quickly released by raising a sliding ring near the heel post, which allows the

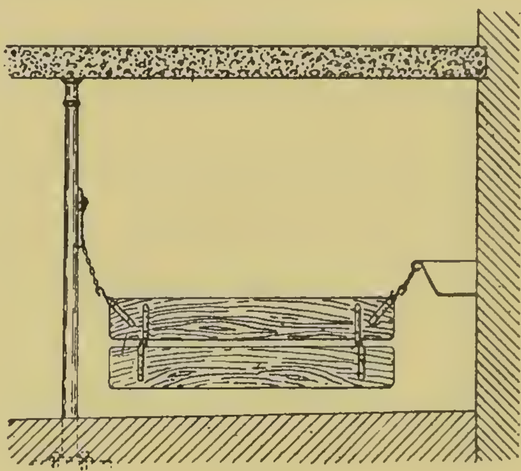


Fig. 152.

hinged hook or catch supporting the bail end to fall down. Self-acting bail attachments may also be obtained, the bail being so hung that the slightest vertical pressure causes the bail to fall to the ground.

Bails consisting of a stout iron rod or tube are sometimes used instead of the wooden planks just described. Those used in army stables in this country are of this character.

At one time the manger fittings for stables consisted of a wooden feeding trough and sloping hay-rack above. They are still used for buildings of cheap construction. Not only are they easily damaged and destroyed by the horses' teeth,

but there are serious sanitary objections to them. Wooden mangers and hay-racks provide a very favourable medium for the retention of disease germs, owing to the absorbent nature of the material, so that infection is liable to be transmitted from one animal to another by their use. These fittings should

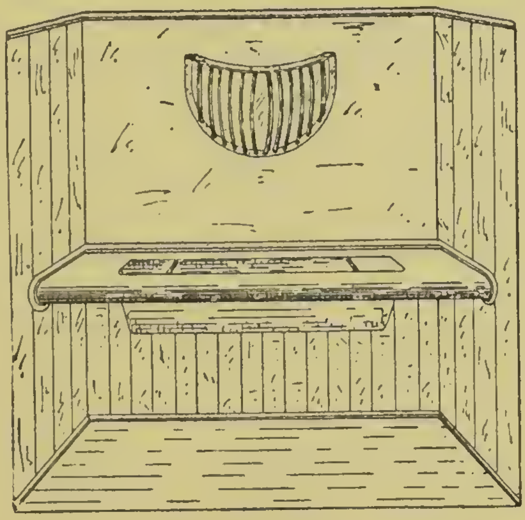


FIG. 153.

therefore be constructed of impermeable materials with a smooth surface, so that they may be easily cleaned. Sometimes mangers of glazed earthenware are used, but they are very apt to be damaged by rough usage. For general

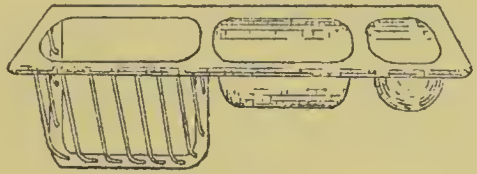


FIG. 154.

purposes iron mangers and hay-racks are found to give the most satisfactory results.

Fig. 153 shows a cast-iron manger pan with wrought-iron *overhead* hay-rack, whilst Fig. 154 is an illustration of the ordinary form of manger pan, with water pot and *underhead* hay-rack.

Another form of fitment is seen in Fig. 155, in which the hay-rack is fixed at the same level as the top of the manger. This latter arrangement is now generally considered to possess certain advantages over the two previously

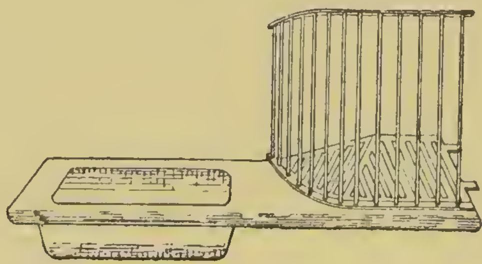


Fig. 155.

shown, as it permits the horse to extract the hay from the rack at the same level as its head, and so feed in a comfortable and unrestrained position.

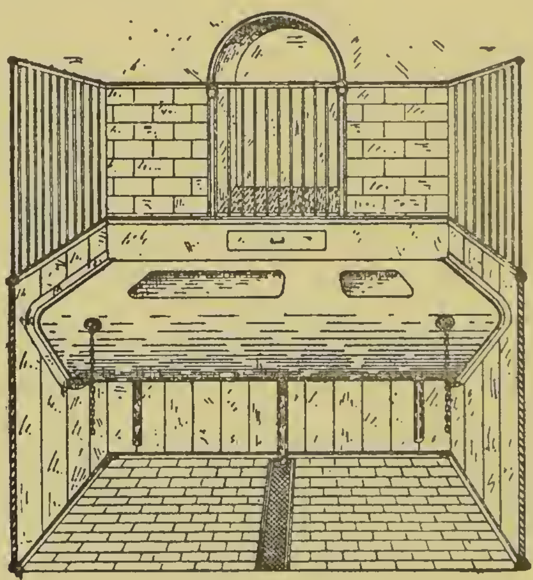


Fig. 156.

A modification of the last-mentioned type of manger-fitting is given in Fig. 156, the hay-rack being placed directly in front of the manger instead of at the side. A shallow recess is formed in the wall to contain the fodder, so

that the rack grating is flush with the face of the wall. Any seeds or particles of dust fall into a seed box or drawer below, which is removed and emptied from time to time.

When *overhead* racks are used, the animal is compelled to raise the head much higher than its normal position for every mouthful of hay that is taken, whilst the hay seeds and dust fall directly into the eyes and nostrils, thus causing a general sense of discomfort.

Underhead racks, when made very deep, are objectionable, as the horse's head is liable to be injured on being suddenly withdrawn when disturbed whilst feeding. With some animals they are also the cause of fodder being wasted, as a horse will frequently turn out the coarser or inferior portions of hay with his nose, and these—falling on the floor—are trampled upon and rendered useless for feeding purposes. To avoid waste under such circumstances some underhead racks are provided with a sliding grid which rests on the top of the hay, and prevents the animal withdrawing more than a mouthful at a time.

For general purposes the manger fittings should be placed from 3 feet 3 inches to 3 feet 7 inches above the floor level (according to the size of the animal), and in fixing them it is necessary that they should be so arranged as to prevent the horses striking themselves on the under side of the manger when rising suddenly from the floor. This may be effected by forming a slope or ramp to the lower portion of the wall at the head of each stall, as shown in Fig. 142. The under side of the manger may also be boarded-in if preferred, or another method is to enclose it with a wrought-iron guard as in Fig. 157, which is a sketch of a well-known registered design. What are known as *safety* manger fittings for stalls and loose boxes are also manufactured, in which the whole of the bottom and front of the manger is smoothly and gradually rounded off in an easy curve, as shown in Fig. 156.

When dealing with horses which are confirmed "crib

biters," other descriptions of fittings may be obtained which have been purposely designed for their use. In this connection the arrangement devised and patented by Professor Varnel for the prevention of crib biting may be briefly mentioned. These fittings, instead of being permanently fixed as in the ordinary method of construction, are pivoted at the lower edge, so that when not in use they are entirely hidden from view by being drawn back into an opening or recess provided in the wall. When they are secured in this position the stable wall then presents nothing but a vertical and even surfacc, leaving no projections which could be

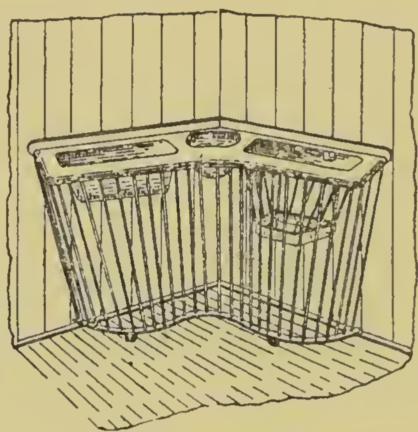


FIG. 157.

grasped by the animal's teeth. Fitments of this description are arranged for use either in stalls or loose boxes.

Whilst measures must be taken to properly secure and confine each horse to its own stall, every facility should be given them to feed freely and to lie down comfortably at any time. The tying apparatus, as generally used, consists essentially of a light chain or leather strap attached to a weight, and sliding freely through a ring in the manger. Fig. 158 shows the general arrangement. For safety, the rising and falling weight is usually enclosed in a cylinder or sheath, as indicated by the dotted lines in the sketch.

For loose boxes a horizontal tying bar, having a sliding

traveller of iron or brass, is used. The sketch of one is shown at A, Fig. 141.

Amongst other minor stable fittings that are required for the complete furnishing of a stable may be noticed the following, viz :—

The 'head-stall fastening.' This consists of a drop ring (as at B, Fig. 141), to which the horse is secured by means

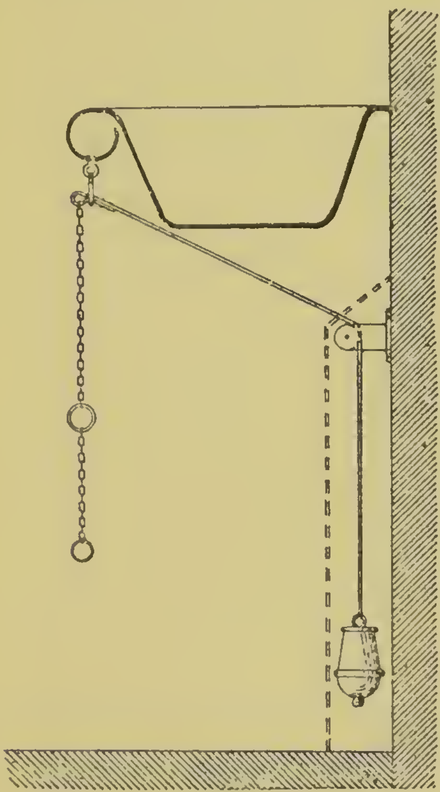


Fig. 158.

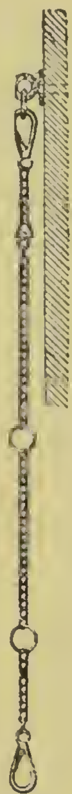


Fig. 159.

Fig. 160.

of a "rack-chain." Fig. 159 shows a rack-chain arranged with a swivel and two rings, together with a spring hook at each end.

Every heel post should also be provided with a drop ring placed in front of the pillar (as at C, Fig. 141), from which a pair of "heel-" or "pillar-chains" may be suspended. Fig. 160 shows a 3-feet 6-inch pillar-chain fitted with a

swivel and two spring hooks, and hanging from the drop ring fixed near the top of the heel post. Two pillar-chains are required for each stall, so that after the horse is completely harnessed it may be secured in a position convenient for leaving the stable when required.

A "name" or "number plate" is also generally fixed at the head of each stall and loose box in well finished stables, as shown at D in Fig. 141. The frame of the name plate is firmly attached to the wall, whilst the panel on which the name appears is arranged in the form of a movable plate which can be taken out at any time, so that any other name or number may be inserted. The plates and frames are made in numerous ornamental designs.

CHAPTER XVII.

HARNESS ROOM AND FITTINGS.

HARNESS ROOM AND FITTINGS:—General construction—Walls to be boarded—Saddle brackets—Pad and collar brackets—Harness hooks—Materials generally used—Case for spurs and bits—Telescopic harness-cleaning hooks—Saddle and harness-cleaning horse—Saddle airer—Girth stretcher.

THE harness room should be placed as near as possible to the stalls and loose boxes, in order that it may be conveniently reached when the various articles of harness are required. The interior should be well lighted, dry, and properly ventilated, the floor being usually formed with $1\frac{1}{2}$-inch deal, wrought, ploughed, and tongued battens on fir joists. Portland cement concrete 6 inches thick, and resting on a 4-inch bed of hard, dry, broken brick rubbish, is previously laid over the whole area under the wooden floor so as to prevent any rising of ground moisture from below.

The walls, instead of being plastered, should be lined with $\frac{3}{4}$-inch deal, wrought, grooved, tongued, and beaded or V jointed boarding, in batten widths, secured to 2-inch by $\frac{3}{4}$-inch deal grounds plugged to the walls, and finished with 1-inch deal moulded skirting 7 inches high, closely scribed and fitted to the floor. The whole of the woodwork is afterwards painted, or sized, stained, and varnished with two coats of best copal varnish.

The general scheme to be adopted in furnishing the harness room will, of course, depend in a great measure on the character of the stable buildings; to suit these varying conditions a large variety of brackets and other fittings are now made by the different manufacturers of these articles.

Figs. 161 and 162 are typical illustrations of brackets suitable for supporting a lady's and gentleman's saddle respectively; whilst Fig. 163 is the sketch of an ordinary bridle bracket. Fig. 164 shows a pad-bracket for single harness, together with a collar bracket at Fig. 165.

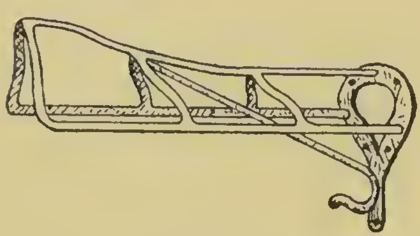


Fig. 161.

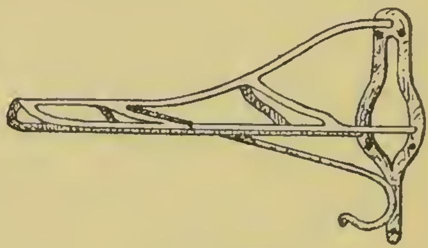


Fig. 162.

A small and useful harness hook is also illustrated at Fig. 166. These fittings are made of wrought or malleable iron, and by their shape allow a free circulation of air throughout. They should be thoroughly well painted or japanned; but in some cases, where expense is not an important consideration, the ironwork is entirely covered with leather. Similar descriptions of harness fittings may also be

Fig. 163.

Fig. 164.

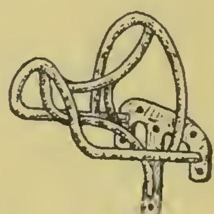


Fig. 165.

Fig. 166.

obtained, which are finished with cappings of polished hardwood properly shaped to the required curve, so that any risk of damage to the harness from the rusting of the ironwork is prevented by this means. The brackets, &c., are fixed to the wall lining in convenient positions, but for stables of a high-

class character they are also enclosed in wall cases, having sliding or hanging doors filled in with glass.

A small case, lined with cloth and having a glazed front, is generally fixed above the fireplace of the harness room. It is fitted with hooks or small brackets to hold spurs, bits, and other polished metal fittings.

Fig. 167 shows a telescopic harness-cleaning hook arranged to hang from the ceiling. It is capable of being adjusted to

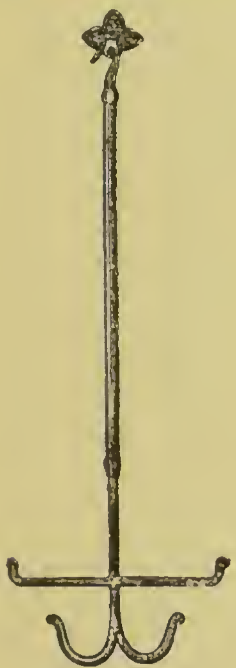


Fig. 167.

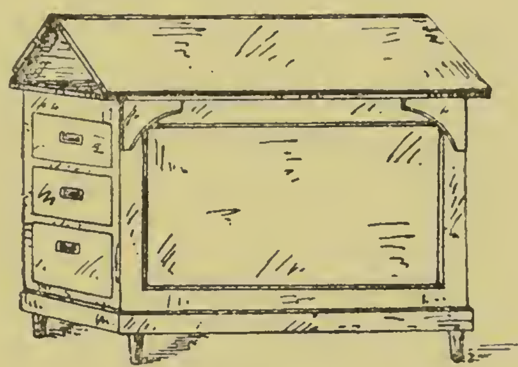


Fig. 168.

any required height, and may be removed when not in use. The cleaning hooks should be covered with leather to prevent injury to the harness.

The "saddle and harness-cleaning horse," shown in Fig. 168, is a very useful and compact article of furniture. Drawers and cupboards are provided for the reception of sponges, brushes, and other cleaning materials. The top is made in two leaves, and designed to turn down so as to form a table when not used for cleaning purposes.

Amongst other requisites that are usually provided may be mentioned a "saddle airer" and "girth stretcher." In general appearance the "saddle airer" resembles an easel or stand, on which the saddle is fixed when placed to dry in front of a fire or in the open air. The "girth stretcher" consists of an iron or wooden frame on which the damp girths are stretched whilst drying.

CHAPTER XVIII.

COW-HOUSE FITTINGS.

COW-HOUSE FITTINGS:—Sanitary requirements—Wooden fittings—Stall division with iron ramp, sill, and posts—Alternative arrangement with lifting boards—Iron stall divisions, troughs, and racks—Stoneware feeding troughs—Manger blocks with roll to prevent waste of food—Cast-iron troughs.

THE sanitary objections to the use of wood for stable fittings have already been mentioned, and they apply with equal or even greater force to cow-house fittings made of this material. Should milk become in any way contaminated by disease germs, it provides a most favourable medium for their multiplication and dissemination. Considering that milk in some form or other constitutes a most important article of diet, it is essential that the fittings and everything connected with the cow-house should be constructed of materials which are in themselves impermeable and easily cleaned, so that any risk of harbouring disease may be reduced to a minimum. Fittings which are wholly, or in a great measure, composed of iron or glazed stoneware, may therefore be considered as offering the most satisfactory construction that has yet been introduced for this purpose.

For cow-houses of an ordinary class the stall divisions are built entirely of wood, in a manner similar to that already illustrated and described in Fig. 143; sometimes an iron sill, heel post, shoulder post, and top rail or ramp is provided, as shown in Fig. 169. An iron vertical tie bar is attached to the shoulder post, on which the binding chain may slide up and down. A modification of the preceding type of stall

division, as made by Messrs. Young & Co., is shown in Fig. 170, having a heel and shoulder post, each provided with a vertical groove in which the division boards are fitted. These boards may be removed at any time to allow of the

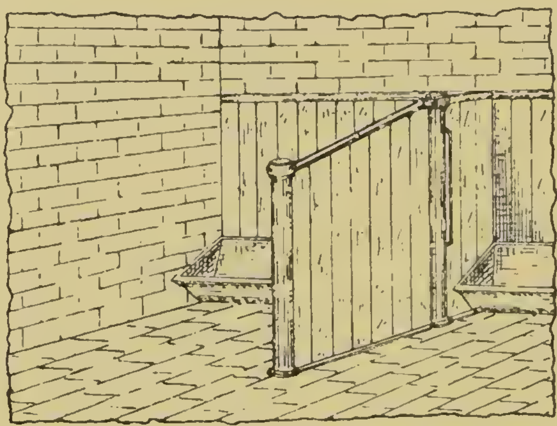


FIG. 169.

building being thoroughly cleansed from end to end. Movable heel posts (standing in iron ground-sockets) can also be obtained if desired.

Stall divisions, which are constructed entirely of iron (Fig. 171), provide one of the most sanitary forms of this

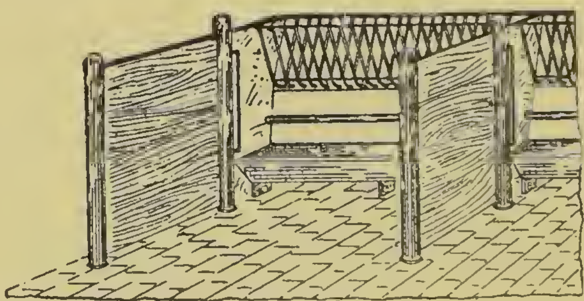


FIG. 170.

class of fitting. The illustration shows a complete "standing" for two cows, as made by Messrs. McDowall, Steven, & Co. and other specialists of stable fitments. It comprises the usual wrought-iron tying bar at the head of the division,

together with an enamelled cast-iron feeding trough and hay rack above.

Feeding troughs of well glazed stoneware are thoroughly impervious and readily cleaned, but the glazed surface is apt to be damaged by rough usage. Fig. 172 is a section through a feeding trough formed with special made manger blocks, and a sketch of the manger, complete with moulded and stopped ends, is shown in Fig. 173. The blocks are formed

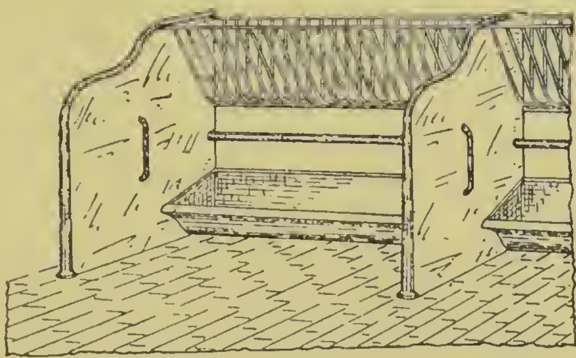


FIG. 171.

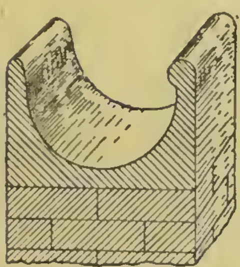


FIG. 172.

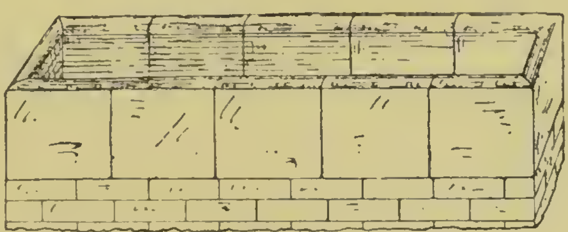


FIG. 173.

with a rolled edge on the inside to prevent the cattle throwing out and wasting the food. Manger blocks having a roll on both the inside and outside edge may also be obtained.

Cast-iron feeding troughs are well adapted for heavy wear, and are extensively used; the best descriptions being porcelain enamelled on the inside. An illustration of a cast-iron feeding trough is shown in Fig. 171, but they are manufactured in a great variety of sizes and sections to suit different requirements.

CHAPTER XIX.

PIGGERIES.

PIGGERIES:—Insufficient attention paid to sanitary construction—Necessity of thorough and periodical cleansing—Disease in pigs largely due to unwholesome conditions of life—Properly designed buildings advantageous from a monetary standpoint—General arrangement and construction of pigsties—Drainage—Materials and finishings for enclosure walls—Feeding troughs—Food store.

As a rule, very little attention is given to the hygienic construction of this class of building; in fact, judging from appearances, it would seem as if the owner considered filth, fœtid air, and excessive damp or moisture to be congenial to pigs, if not absolutely favourable to their welfare. Swine may be comparatively gross and dirty in their habits of feeding, but this trait is unfortunately often aggravated by making them perform the duties of a domestic scavenger, insomuch that garbage of all kinds is given them for food. It is doubtless very probable that preconceived ideas of this description account in some measure for the lack of attention which is given to the proper housing of these animals.

The piggeries are seldom or never thoroughly cleansed. Generally it is considered quite sufficient if any excess of manure is removed at irregular and infrequent intervals, so that considering the whole of the circumstances, it speaks volumes for the average vitality of pigs that they are able to thrive at all when kept in confinement under such unfavourable conditions.

Insanitary surroundings, combined with improper and unwholesome food, are undoubtedly largely responsible for the epidemics which often occur amongst these animals—

viz. swine plague, typhoid, &c., and also to the presence of such diseases as trichina and the various other parasitic worms with which they are oftentimes infested. The prevalence of tapeworm and trichiniasis in the human intestines is largely due to the consumption of unsound and insufficiently cooked pork. Considering that pigs are kept for the purpose of ultimately becoming human food, it is important that they should at least be maintained under such conditions that their physical well-being may not be detrimentally affected. Even from a monetary point of view, it is advantageous to provide properly constructed buildings and maintain them in a sanitary state; for not only are the

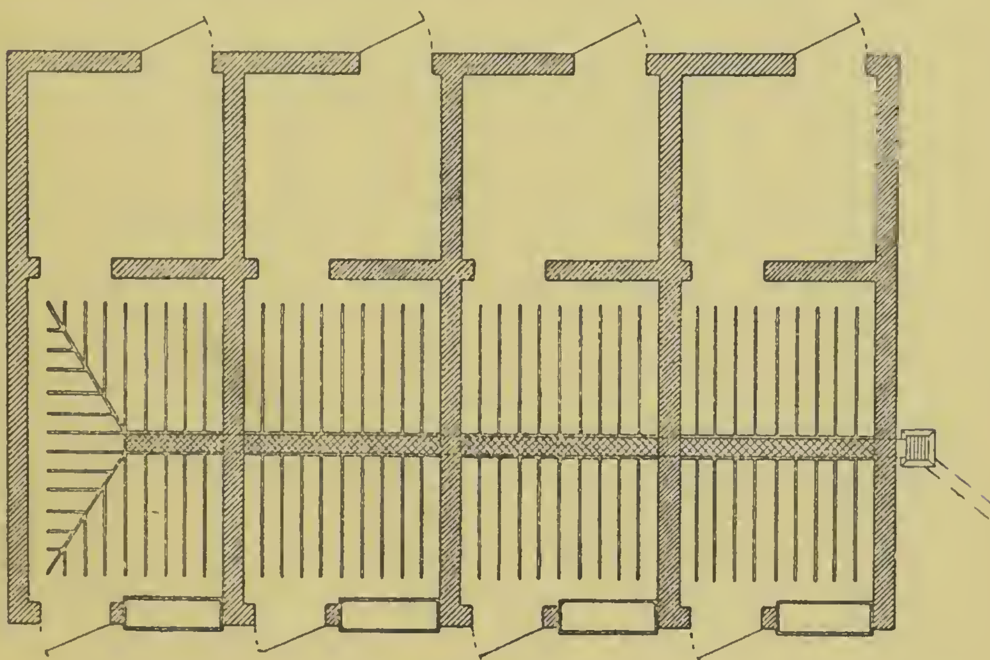


FIG. 174.

swine less subject to disease, but they thrive better and are altogether more healthy, and consequently more marketable than when living amidst dirt and putrefying refuse.

Fig. 174 is the plan of a range of four pigsties or pens. Each sty consists of a covered sleeping place or "box," with an open run or feeding yard attached. The walls are of

brickwork 9 inches thick, and the roof covered with slates or galvanised corrugated iron. To ensure adequate ventilation a course of ventilating air bricks (similar to those shown in Figs. 13 and 14) should be inserted at the eaves level in the front and rear walls, whilst a small wooden louvred ventilator is provided at the ridge.

The door at the rear of each box should be hung in two heights, so that the upper half may be opened and the interior inspected at any time without disturbing the swine. Another advantage is that in fine weather the upper portion of the door can be fastened back against the wall, thus allowing a free circulation of air to take place within. A sliding door or falling shutter may be provided to the opening between the "box" and the yard, so as to confine the animals to the building when necessary. An entrance door to each yard is also provided, as indicated on the plan.

If practicable, it is desirable to arrange the piggeries so that an extensive grass run or field is available for the pigs to roam about in at convenient times.

The floor of the piggery, both of the yard and box, should be of some hard, non-absorbent material, in order that it may fulfil the same conditions as already laid down for stable paving. Any of the bricks mentioned as suitable for the floors of stables and cow-houses may be used, but for general purposes it is considered that the most satisfactory results are obtained with concrete paving of good quality, as there is an entire absence of joints. The paving, whether of brick, concrete, or other material, should be laid on a layer of well rammed, hard, dry rubbish. By this means the under surface of the paving is rendered comparatively dry, and any rising of ground moisture or damp will be largely prevented. The floor of each box should be slightly raised above that of the yard and well currented to proper falls, so that the whole of the surface drainage of the interior is discharged directly outside through the door opening.

No trapped gullies should be allowed inside the boxes or

yards of the piggeries, the liquid sewage being entirely removed by surface channels to one or more gullies placed immediately outside the enclosure. In Fig. 174 a surface channel is shown passing through the centre of each yard, the paving being properly currented towards it. The main channel may be left quite open, or covered with a perforated grating as indicated on the plan. Where it passes through the outer wall, an iron grating is provided to keep back pieces of straw, &c., and to prevent the entry of vermin. A trapped gully receives the liquid discharge from the main channel.

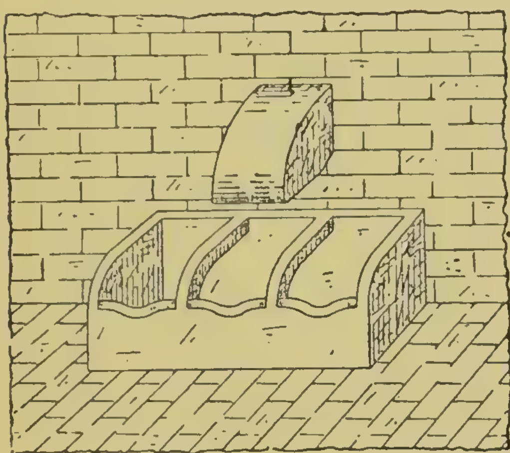


Fig. 175.

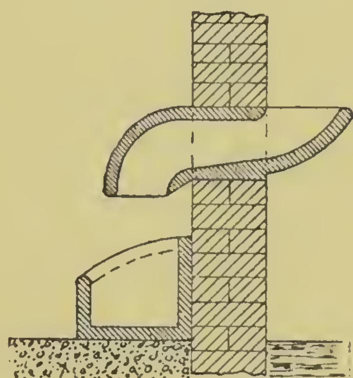


Fig. 176.

The enclosure walls of the yards are sometimes constructed with galvanised corrugated sheet iron, or iron standards and plates, instead of brick or stone. Where the latter materials are used the walls should be finished with a Portland cement skirting $\frac{3}{4}$ inch thick and about 12 inches high, in order to prevent the lower portion of the walls becoming impregnated with sewage. The upper edge of the skirting should be weathered or chamfered, and the entire surface trowelled perfectly smooth so that it may be easily cleaned. Walls built with a facing of salt-glazed bricks also provide an impervious and easily cleaned surface.

Feeding troughs of iron or glazed earthenware are generally used. Figs. 175 and 176 show the elevation and section of a strong, salt-glazed earthenware pig trough, as made by Messrs. Oates and Green. The food shoot is built into the wall, so that the trough may be conveniently filled from the outside.

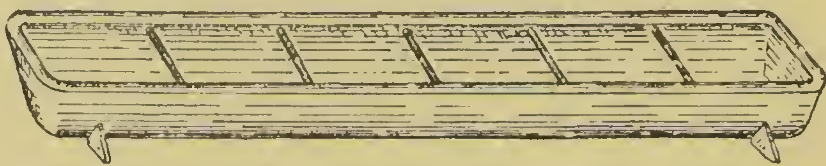


FIG. 177.

The ordinary form of portable cast-iron pig trough is illustrated in Fig. 177.

An improved type of iron trough is shown in Fig. 178, as constructed by the St. Pancras Ironwork Co. and other well-known firms. It is fixed between two iron standards, the lower half of the front over the trough being hinged, and

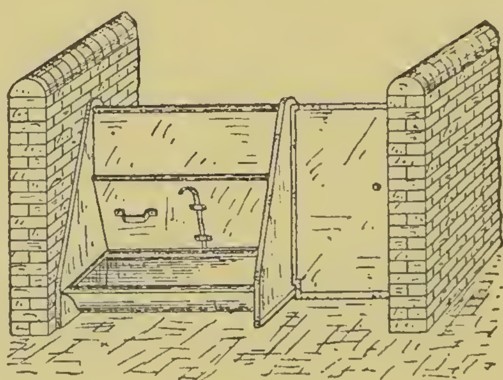


FIG. 178.

provided on the outside with a handle and sliding bolt. The trough is filled from the outside by pushing forward the swing shutter, and securing it in that position by the bolt, so that the swine cannot reach the trough during that time. After pouring in the food, the shutter is drawn back and fastened to the opposite side of the trough in order to give

the animals free access thereto. The illustration also shows an iron door hung to one of the standards.

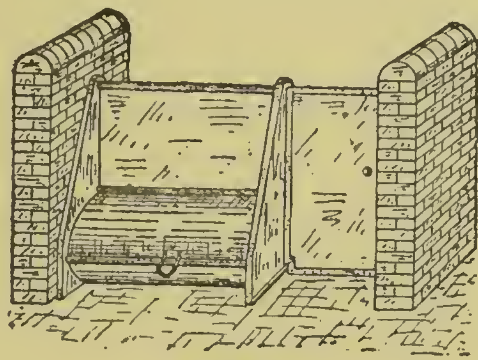


FIG. 179.

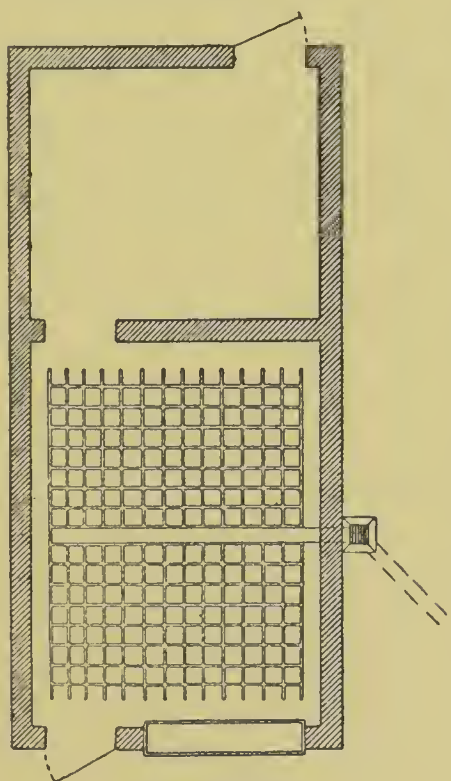


FIG. 180.

Fig. 179 shows another arrangment differing slightly from that just described, the trough shutter or cover being made

to partially revolve, instead of swinging from its upper edge.

Piggeries designed to accommodate one or two pigs each should have boxes not less than 6 feet by 6 feet, the size of each yard or run being about 6 feet by 9 feet. When it is intended to house a greater number of animals in each piggery, the size of the boxes and yards should be proportionately increased. For breeding purposes the boxes should be about 9 feet by 8 feet, with a yard enclosure of 9 feet by 12 feet (Fig. 180), so that the young litter may have plenty of space.

A complete and self-contained piggery should include a food store, placed in some convenient situation and fitted with a boiler for cooking the food, together with a tank in which the prepared food may be stored until required for use.

As in the case of stables and cow-houses, the piggeries should be thoroughly and frequently cleansed by hand so as to maintain them in a sweet and wholesome condition. The interior of the boxes should also be lime-whited at stated intervals.

CHAPTER XX.

KENNELS.

KENNELS :—General remarks—Buildings to be on high and dry ground—Paving — Drainage — Enclosures for dog runs —Water troughs — Kennels to be well lighted and ventilated—Doors—Angles of door jambs to be provided with rollers—Benches — Boiling house and feeding room—Dog runs roofed in with corrugated iron.

BUILDINGS intended for housing dogs differ somewhat in design and general arrangement according to the breed which it is proposed to accommodate. They may vary from the simple and inexpensive hutches which serve for the shelter of domestic pets and watch dogs, to the extensive range of buildings required for a pack of harriers or fox-hounds. The following remarks will, however, be confined to the general details of construction relating to the erection of kennels for dogs which are kept in comparatively large numbers for sporting purposes.

Fig. 181 is a typical plan for a range of kennels suitable for a small pack of harriers or fox-hounds. The centre block comprises a feeding and boiling house, together with extra rooms or stores on the first floor. At one side is placed two large kennels for dogs, the other side being arranged with three small houses for bitches in whelp, and a sick box at the extreme end. All the boxes or kennels are conveniently reached from the feeding house by means of covered passages. An enclosed and paved run is provided to each kennel, whilst beyond these a good-sized field or extensive grass run should be available in which to exercise the dogs at stated intervals.

Wherever practicable, the buildings should be erected on

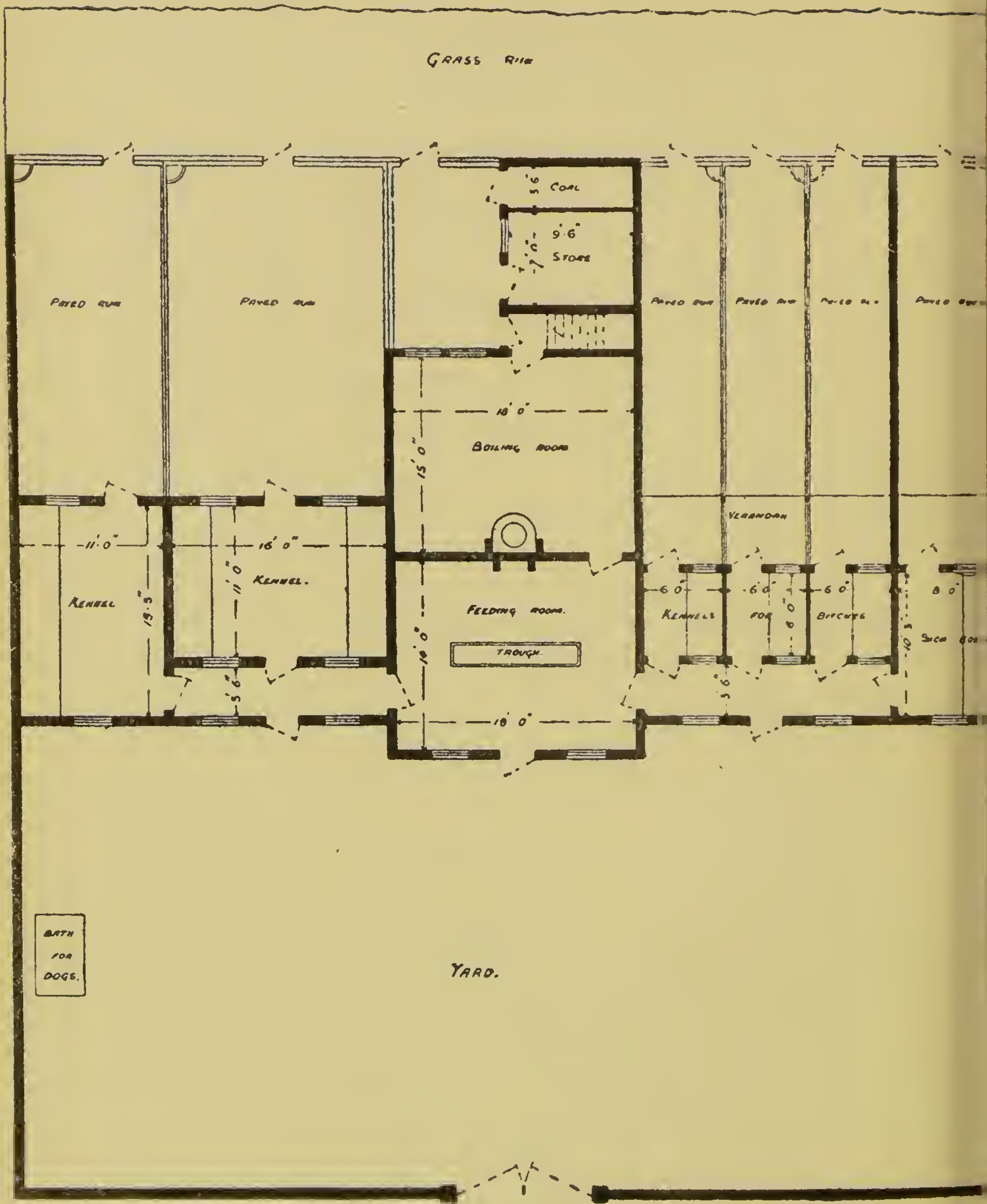

GRASS RUN
PAVED RUN
PAVED RUN
COAL
9·6
STORE
PAVED RUN
PAVED RUN
18' 0"
BOILING ROOM
15' 0"
VERANDAH
11' 0"
16' 0"
KENNEL
KENNEL.
FEEDING ROOM.
TROUGH.
KENNELS
FOR
BITCHES
18' 0"
BATH FOR DOGS.
YARD.

FIG. 181.

high and dry ground, but sheltered from prevailing winds, the runs being arranged with a south aspect.

The kennels must be paved with some non-absorbent material possessing a smooth and easily-drained surface. Stable-paving bricks, asphalt, pressed tiles, or concrete may be used. It is desirable to lay the paving on a concrete foundation laid on 6 inches of well rammed broken-brick rubbish, so as to ensure a dry surface. The whole of the floor should be laid to proper falls, together with the provision of such surface channels as may be found necessary for the complete removal of waste liquids.

Nothing but surface drainage should be permitted either within the boxes or paved runs. Trapped gullies must be conveniently placed outside the kennels, in order to receive the discharge from the surface channels.

A dwarf wall about 2 feet 6 inches high, surmounted by a wrought-iron railing 4 or 5 feet in height, encloses each of the paved runs, whilst a small gate at the further end provides a means of access from the kennels to the field or grass run beyond. The railing must be strong, and should have ½-inch diameter wrought-iron vertical bars spaced 2½ inches apart, with 1½-inch by ½-inch horizontal upper, middle, and lower rails, the whole being secured to the coping of the dwarf wall with stout intermediate iron posts spaced about 6 feet apart. The gates are of wrought-iron bars, framed together so as to correspond in general appearance with the railing. The paved run attached to the sick box is separated from that of the adjacent kennel by means of a brick wall carried up to a height of 6 feet. All the paved runs are finished with a ¾-inch cement skirting, chamfered on its upper edge.

An enamelled iron trough containing drinking water (soft water preferably) for the dogs should be provided to each kennel in some convenient position. In the foregoing plan an angular drinking trough is shown at the extreme end of each paved run.

In Fig. 181 it will be observed that the roof over the

bitch houses and sick box projects beyond the front wall for some considerable distance, so as to cover in a portion of the yard, thus forming a verandah. When rearing litters of young puppies, and also for invalid or sick dogs, the extra protection against the weather which is obtained by this means is of great benefit.

The kennels should be thoroughly well lighted and ventilated, for an ample supply of light and air is as essential to the physical well-being of dogs as of men. The walls should not be less than 7 feet 6 inches in height, so as to afford adequate internal cubic space. Low-level fresh-air inlets should be provided near the floor, together with a continuous ventilating course near the eaves. The warm vitiated air can be simply and efficiently removed by means of continuous ridge ventilation, or by using a good type of exhaust ventilator.

A small window (size about 2 feet 6 inches by 1 foot 7 inches) inserted in the front and rear walls of each box will generally be found to give sufficient light. Where large-sized houses or kennels are built, additional windows must, of course, be provided. In all cases it is desirable that the windows be made to open so that the interior may be well flushed with air at any time.

It is a good plan to have the doors at the front and rear of the boxes made and hung in two heights. At night time the upper portion of the front door may be closed, the lower half being left partly open and secured in that position by means of a hinged stay bar, so as to give the dogs free access to the paved run when necessary; whilst in the day time the whole of the door can be thrown back and secured to the face of the wall.

The angles of the door jambs of large dog kennels are provided with metal rollers revolving loosely on pivots, in order that the dogs may not be bruised or injured when rushing out in a body. A similar device consists in threading a number of porcelain or metal balls (about the size of a

billiard ball) on an iron bar as indicated in Fig. 182, so that each ball is free to revolve on its own axis when touched.

The benches of dog kennels should be designed to retain as little dirt and moisture as possible, whilst every part should be readily accessible for cleaning. They should be constructed of some hard and comparatively non-absorbent wood, such as oak or teak, rather than of deal or other soft wood.

A very simple and efficient arrangement of kennel bench appeared some years ago in the *Field*, when a correspon-

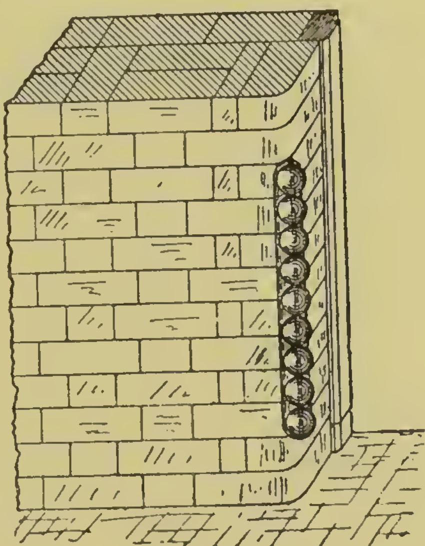


Fig. 182.

dent, writing under the nom-de-plume of "Lepus," gave a sketch of a bench as used by him (see Fig. 183), together with the following description, viz:—

"My benches are made of inch deal, cut into widths of 3 inches, and nailed ½ inch apart to two transverse pieces, to which hinges are fixed to connect the bench with a board 6 inches wide, fastened firmly to the wall about a foot from the ground. In front is a piece of board about 3 inches in width, to keep the straw from drawing off with the hounds. To prevent the hounds from creeping under, I nail two long

laths, the length of the bench, across in front of the legs, which are hung with hinges in front of the bench, so that when the bench is hooked back they fall down and hang flat. By having the 6-inch board between the hinges and the wall, it prevents the former from being strained when the bench is hooked back with straw upon it."

An improved form of bench—comprising both a day and night bench—may be obtained from manufacturers of kennel fittings. It is designed with a double floor or seat, and in most cases both the upper and lower seat are formed of open battens. The upper seat is made to fold up with the

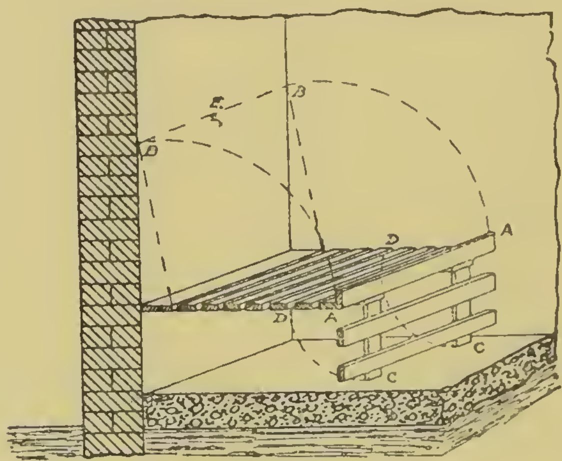


FIG. 183.

bedding, and is secured to the wall by hooks, so that the straw may be kept quite clean and dry. During the day-time the dogs rest on the lower seat of the bench instead of on a cold concrete or brick floor, but the whole bench may be turned up in order to allow of the entire floor being thoroughly cleansed. At night the upper seat (together with the bedding) is turned down to provide a comfortable sleeping place for the dogs. Sometimes the walls of the boxes are boarded, or rendered in cement, to a height of 2 feet 6 inches above the bench, instead of leaving the rough surface of the brickwork exposed at this point. The interior

of the kennels must be periodically white-washed, so that they may be maintained in a clean and wholesome condition.

The boiling house should be provided with a large boiler for cooking the food, or better still, with two boilers, so that one may be entirely reserved for cooking oatmeal, &c., whilst the other is used for boiling all the animal food that may be required. A good supply of hot and cold water should also be available at any time. The feeding room is fitted up with a long trough, in which is placed the dogs' food for each meal time.

In front of the buildings a large courtyard is arranged, and finished with a paved or gravelled surface. This enclosure forms a convenient gathering ground for the hounds, the various kennels having direct access thereto. A bath or washing place for the dogs is also provided in the courtyard.

Kennels such as those just described are well adapted for hardy breeds of dogs, such as fox-hounds, harriers, &c.; but for greyhounds and other varieties of dogs which can only be brought to a high condition of health and speed by very careful attention and gentle nurture, it is necessary that the general arrangement of the buildings shall be slightly modified to suit the altered conditions. Amongst other minor matters, it is desirable that the paved runs should be entirely roofed in, so that both the boxes and yards may be thoroughly protected from the weather. The runs can be cheaply covered in by using corrugated iron. The sides of the runs should, however, be finished with a dwarf wall and open iron railing in the usual manner, so that ample ventilation may be obtained.

CHAPTER XXI.

AVERAGE COST.

Average Cost:—A knowledge of the cost of buildings useful—Cost varies in different parts of the country—Average cost of stables—Saddle and harness rooms—Forge and shoeing shed—Coach-houses—Cow-houses—Stable fittings—Cow-house fittings—Stable paving.

Some knowledge of the average cost of the different classes of stables, cow-houses, &c., is frequently of great service to those who are directly concerned in the construction of buildings of this character. Such information is found to be more especially useful to architects and others during the initial stage of preparing designs which, when carried out, must not exceed a certain specified amount. Of course, the cost of erecting the same class of building will vary in different parts of the country, as the local circumstances of each place must materially affect the ultimate cost. For instance, whilst a stable of a certain description might be erected for 50*l.* per stall in one part of the country, yet a precisely similar building may cost not less than 60*l.* per stall in another locality.

The following items may, however, be useful for comparison, as showing in broad and general terms the average cost of stable buildings of various descriptions, together with their accessories. The prices refer to brick buildings of a substantial character, and covered with slates unless otherwise stated. In cases where the average cost is given at per foot cube, it is assumed that the cubic contents of the building have been ascertained by taking the dimensions from out to out of walls, and from the bottom of the footings to half-way up the roof.

First-class stables, such as are erected for the best description of racing, hunting, or private establishments, cost from 120*l.* to 150*l.* per horse. Where the accommodation consists almost entirely of loose boxes, the cost will in some cases exceed the amount given.

Second-class stables, comprising those which are ordinarily attached to large town and country houses, well and substantially finished, may be erected for 70*l.* to 90*l.* per horse.

Third-class stables, intended to accommodate large numbers of horses, and provided with swing bails or plain stall partitions, as for tramway and omnibus companies, general carriers, &c., cost about 45*l.* per horse.

Fourth-class stables, such as are generally provided for small hotel, livery, and hackney purposes, cost about 40*l.* per stall.

Fifth-class stables, of the type usually erected for farmsteads, cost from 30*l.* to 35*l.* per stall.

Saddle and harness rooms cost from 6*d.* to 8*d.* per foot cube, according to the amount of finish given to the interior and the class of fittings provided.

The average cost of a smithy, or forge and shoeing-shed, fitted complete, with bench, racks, vices, anvils, bellows, &c., may be taken at 6½*d.* per foot cube.

Coach-houses, stores for forage, and buildings of a similar character vary from 3*d.* to 5*d.* per foot cube, the exact value depending on the size of the rooms and the amount of finish required.

First-class cow-houses, provided with superior iron fittings, &c., complete, cost from 25*l.* to 30*l.* per cow.

Second-class cow-houses, including iron fittings of a plain and substantial character, may be built for 20*l.* per cow.

Third-class cow-houses, as for farm buildings, cost from 14*l.* to 16*l.* per cow.

As regards the average cost of cow-houses here given,

the prices refer to buildings in which each stall is arranged to accommodate two cows.

The dimensions and details of construction of piggeries and kennels vary to such a large extent, and depend so much on local circumstances, that no general guide as to their average or comparative cost can be given.

The cost of providing and fixing stable fittings and accessories varies considerably, but chiefly on account of the general design and finish which may be required. The following prices may be taken as showing the approximate and comparative value, so far as it can be stated in general terms.

Iron stall fittings of an ornamental character, for stables of the highest class, and comprising a stall partition with ventilating ramp, sliding barriers, enamelled manger fittings with safety front, hay rack, pillar-chains, head-chains, &c., fixed complete, cost from 20*l.* to 30*l.* per set.

Plain but well-finished fittings, comprising iron sill and ventilating ramp, 1½-inch boarding, iron heel post, manger, hay-rack, chains, &c., fixed complete, cost about 16*l.* per stall. For stable buildings of an ordinary character, the price of the fittings averages from 7*l.* to 10*l.* per stall, fixed complete.

Iron cow-house fittings of the best class cost about 8*l.* per cow, including iron heel post and stall division, feeding trough, fodder rack, fastening rods, chains, &c., fixed complete, and assuming that one stall division is provided to every two cows. Fittings of a similar but plainer type, such as are well adapted for ordinary buildings, average from 4*l.* to 6*l.* per cow, including fixing.

Concrete stable paving 3 inches thick, composed of clean granite chippings and Portland cement, grooved and laid complete to proper falls, on and including a Portland cement concrete foundation 6 inches thick, with 6 inches of broken brick rubbish under, costs about 11*s.* 6*d.* per yard super.

The average price of paving with granite setts 6 inches deep, on and including concrete foundations 6 inches thick, is 21*s.* 6*d.* per yard super.

Paving with plain Dutch or adamantine clinkers, on and including concrete foundation and brick rubbish as before, costs approximately 15*s.* per yard super. If the clinkers are formed and laid with bevelled edges or panels, then 1*s.* per yard super. must be added to the foregoing price.

Blue Staffordshire chamfered stable bricks, 9 inches by 4½ inches by 3 inches, laid complete with concrete foundations, &c., as already described, may be carried out for 11*s.* 6*d.* per yard super.

The price of wood-block paving, consisting of creosoted red deal blocks 9 inches by 3 inches by 6 inches, laid complete on 6 inches of cement concrete, with a bed of broken brick rubbish under, the joints being grouted with bitumen, or cement and sand, is about 14*s.* per yard super.

For any further information respecting the methods generally adopted in the preparation of preliminary estimates, and the average cost of various descriptions of buildings, the reader is referred to a small work entitled 'A Price-Book for Approximate Estimates,'* in which the subject will be found to be more fully considered.

It would occupy too much space, and also greatly exceed the limits of the subject as originally laid down for consideration in these pages, to enter into any further particulars respecting the average cost of stable accessories and sundries. The specific cost of any particular fitment or article may be readily obtained from manufacturers and firms engaged in carrying out work of this description, more especially as the local requirements or conditions would then be known and due allowance could be made for them.

* 'A Price-Book for Approximate Estimates,' by T. E. Coleman, F.S.I., 2*s.*, E. & F. N. Spon, Ltd., London.'

CHAPTER XXII.

LEGISLATIVE MEASURES.

LEGISLATIVE MEASURES :—The prevention of disease amongst animals—Contagious Diseases (Animals) Act—Powers of the Local Government Board—The Dairies, Cow-sheds, and Milk Shops Order—Regulations of the London County Council—The London Building Act—The Public Health (London) Act.

WE have now considered in detail some of the best and most modern methods of constructing different descriptions of stable buildings so as to secure thorough sanitary efficiency. By such means every reasonable precaution may be provided to ensure a maximum degree of health and comfort for the occupants. Before leaving the subject, however, it seems desirable to make a brief reference to the ordinances which, from time to time, have been enacted by Parliament concerning the construction of buildings of this character, and the powers which have thereby become vested in the local authorities throughout the country.

Many of the various legislative measures have primarily for their object the prevention of disease amongst those animals which are in any way used for human food. Of this class cattle form by far the most important section, for their flesh not only provides the largest proportion of the total quantity of animal food consumed by man, but cow's milk is also in itself a staple article of every-day diet. As a consequence, the regulations bearing upon stable construction are confined almost entirely to the sanitary condition of cow-houses, dairies, and their accessories.

The Contagious Diseases (Animals) Act of 1878, 41 and 42 Vic., c. 74, as amended by the Contagious Diseases (Animals) Act of 1886, 49 and 50 Vic., c. 32, sets forth the measures

which must be taken under certain circumstances for the prevention and stamping out of infectious diseases amongst animals. For the purposes of this Act it is laid down that wherever the word "animals" is used therein it includes cattle, sheep, goats, and swine, whilst the word "cattle" is still further defined as embracing bulls, oxen, cows, heifers, and calves.

Under this Act full powers are also vested in the Local Government Board to make such general or special orders as they may think fit for the following purposes, viz.:—

I. The registration with the local authority of all cow-keepers and dairymen.

II. The inspection of cattle in dairies, and for prescribing and regulating the sanitary construction of all cow-sheds occupied by cow-keepers or dairymen.

III. For securing the cleanliness of milk stores and shops, and the milk vessels used therein.

IV. For prescribing precautions to be taken for protecting milk against infection or contamination.

V. For authorising a local authority to make regulations for the purposes aforesaid, subject to the conditions prescribed by the Local Government Board.

The regulations which govern the registration of dairymen, together with the water supply and sanitary condition of dairies and cow-houses, are fully set forth in the "Dairies, Cow-sheds, and Milk Shops Order of 1885, as amended by the Dairies, Cow-sheds, and Milk Shops amending Order of 1886." This order extends to England, Wales, and Scotland only, and the more important of its provisions are summarised as follows:—

Section 6 refers to the registration of cow-keepers and dairymen by the local authority.

Section 7 provides that all cow-keepers or dairymen intending to occupy a building as a cow-shed or dairy which has not been previously so occupied, must first give one month's notice to the local authority: also that the lighting, ventilation, air space, cleansing, drainage, and water supply

of such buildings must be carried out to the reasonable satisfaction of the local authority.

Section 8 states that "it shall not be lawful for any person following the trade of cow-keeper or dairyman to occupy as a dairy or cow-shed any building, whether so occupied at the commencement of this order or not, if, and as long as, the lighting and ventilation, including air space, and the cleansing, drainage, and water supply thereof are not such as are necessary or proper—

"(*a*) For the health and good condition of the cattle therein.

"(*b*) For the cleanliness of milk vessels used therein for containing milk for sale.

"(*c*) For the protection of the milk therein against infection or contamination."

Section 9 enacts that it is unlawful for any person suffering from a dangerous infectious disorder, or who has recently been in contact with a person so suffering, to milk cows, handle vessels, or in any way take part in the production, distribution, or storage of milk until all danger of infection or contamination has ceased.

Section 10 provides that no water-closet, earth-closet, privy, cesspool, or urinal shall be within, or communicate directly with, or ventilate into, any dairy or room used as a milk store or milk shop.

Section 11 prescribes that no milk store or milk shop shall be used as a sleeping apartment, or for any purpose which is likely to cause contamination of the milk.

Section 12 declares it to be unlawful for a cow-keeper, dairyman, or purveyor of milk to keep swine in a cow-shed, milk store, or any place used for keeping milk for sale.

Section 13 empowers the local authority to make regulations for—

(*a*) The inspection of cattle in dairies.

(*b*) Prescribing and regulating the sanitary arrangements of dairies and cow-sheds occupied by cow-keepers or dairymen.

(*c*) Securing the cleanliness of milk shops and all vessels used therein.

(*d*) Prescribing precautions against the infection or contamination of milk.

Section 14 provides that all such regulations shall be first submitted to the Local Government Board for approval, and afterwards advertised in the local newspapers.

Section 15 states that "if at any time disease exists among the cattle in a dairy or cow-shed, or other building or place, the milk of a diseased cow therein—

"(*a*) Shall not be mixed with other milk.

"(*b*) Shall not be sold or used for human food.

"(*c*) Shall not be sold or used for food of swine or other animals unless and until it has been boiled."

As already mentioned, the regulations made by the various local authorities are based upon the "Dairies, Cow-sheds, and Milk Shops Order, 1885–6," of which the foregoing is a brief outline.

The by-laws enforced by the London County Council respecting the sanitary conditions of all dairies, cow-sheds, and milk shops embraced within their jurisdiction are now given for purposes of reference.

Regulations as to Dairies, Cow-sheds, Milk Shops, &c., and as to Precautions against the Infection and Contamination of Milk in the Metropolis.

(The powers and duties of the Metropolitan Board of Works have been transferred by the Local Government Act, 1888, *to the London County Council, and any person failing to observe these Regulations will be proceeded against by that Council accordingly.)*

In pursuance of Section 13 of the Dairies, Cow-sheds, and Milk Shops Order of 1885, the Metropolitan Board of Works being the local authority for the Metropolis (except the

City of London and the Liberties thereof) hereby make the following regulations:—

(*a*) For the inspection of cattle in dairies.

(*b*) For prescribing and regulating the lighting and ventilation, cleansing, drainage, and water supply of dairies and cow-sheds in the occupation of persons following the trade of cow-keepers or dairymen.

(*c*) For securing the cleanliness of milk stores, milk shops, and of milk vessels used for containing milk for sale by such persons.

(*d*) For prescribing precautions to be taken by purveyors of milk, and persons selling milk by retail, against infection or contamination.

Regulations.

1. These regulations shall commence and take effect from and immediately after the third day of August, 1885.

2. Every Inspector appointed by the Board under this Act is hereby authorised to inspect all cattle upon the premises of all persons registered by the Board under the Act.

3. Every cow-shed shall be well and sufficiently lighted by openings in the sides or roof, or by windows therein.

4. Every cow-shed shall be thoroughly ventilated by lantern-louvred ventilators in the roof thereof, or by louvred ventilators in the walls, or by openings in the sides or roofs.

5. In every cow-shed there shall be sufficient air space for the health and good condition of the cattle therein, i.e. there shall be for each animal kept in a separate stall a superficial space of at least 8 feet by 4 feet, and for two animals kept in one stall a superficial space of 8 feet by 7 feet, and there shall be an air space of at least 600 cubic feet in respect of every animal kept in a cow-shed, where, taking into consideration the position and construction of the shed, there are perfectly satisfactory means of ventila-

tion; but, in other cases, there shall be an air space of 800 cubic feet in respect of every animal kept, and, in any case, the height of the shed in excess of 16 feet shall not be taken into account in estimating the air space.

6. Every cow-shed shall be well paved with Stourbridge or other impervious brick, or other impervious material, set with cement properly bedded on concrete, with a proper slope towards a gully-hole, which shall, where practicable, be outside the shed; and such gully-hole shall communicate by an adequate drain of glazed stoneware pipes with the public sewer, and be trapped by an appropriate fixed trap, and be covered with a grating, the bars of which shall not be more than $\frac{3}{8}$ inch apart, excepting that not exceeding 3 feet of the foremost part of the stalls may be paved with chalk or other similar material.

7. Every cow-shed shall be provided with an adequate supply of water, and where there is not a constant water supply, with a slate, metal, or metallic-lined tank, properly covered and provided with an overflow or warning pipe, and with piping for conveying the water to the cow-shed; such tank to be so placed that the bottom thereof shall be not less than 6 feet above the floor level. Every such tank shall be of a capacity equal to 12 gallons of water for each cow lawfully kept; it shall have no communication with any water-closet or drain by means of a waste-pipe; and it shall be supplied with good and wholesome water, which, if practicable, shall be procured by the occupier from a public water company, and such tank shall be cleansed as often as is necessary for keeping the same in a clean condition.

8. Each stall or standing-place for cows in every cow-shed shall be provided with a water-trough or receptacle, constructed of, or lined with, hard, smooth, and impervious material, and each such trough or receptacle shall be supplied with water by means of a pipe communicating with a water tank, or, in the case of a constant water supply, with the water company's pipes, and each such trough or recep-

tacle shall also be provided with a waste pipe or waste hole in the lowest part thereof.

9. The inner walls, doors, and woodwork (except the partitions between the cows) of every cow-shed shall be covered with hard, smooth, and impervious material to a height of at least 5 feet from the floor of such cow-shed, and such hard, smooth, and impervious material shall not be covered with cement-wash, lime-wash, or other substance.

10. Every cow-shed shall be provided with properly constructed places or receptacles for storing any brewers' grains intended for the animals therein, and also places or receptacles for receiving the dung and litter from the cow-sheds, and such places or receptacles shall be constructed of, or lined with, impervious material, and be properly drained; but no such places or receptacles shall be within, or communicate directly with, any cow-shed.

11. No water-closet, privy, cesspool, or urinal shall be within, communicate directly with, or ventilate into, a cow-shed.

12. No dung, grains, or other substance from which effluvium is liable to be given off shall be kept in any cow-shed; nor shall any dung, grains, or other substance, as aforesaid, be so kept that any effluvium therefrom can enter any shed.

13. The upper parts of the inner surface of the walls of every cow-shed shall be thoroughly cleansed and lime-washed in the months of March and September, and at other times within seven days of the Board giving notice in writing that such cleansing and lime-washing are necessary.

14. The floor of every cow-shed, and all troughs or utensils used for supplying the cows with food and water, shall be thoroughly cleansed with water at least once every day, and the portions of the walls, partitions, doors, and other parts of the cow-shed within 5 feet of the floor shall be thoroughly cleansed as often as may be necessary for keeping the same in a clean condition.

15. All dung and offensive litter shall be carefully swept up and removed from every cow-shed at least twice every day, and shall be removed from the premises as frequently as may be necessary to prevent nuisance.

16. All utensils and vessels used by a cow-keeper for the reception, storage, or delivery of milk shall be thoroughly cleansed with steam or scalding water as frequently as may be necessary for keeping such vessels and utensils perfectly clean and sweet, and only clean water shall be used for this purpose.

17. Every cow-keeper shall at all times employ such means and adopt such precautions as may be necessary for keeping any cow-shed in his occupation and the cows therein in a clean and wholesome condition.

18. Every dairy shall be sufficiently lighted, and shall be thoroughly ventilated by louvred ventilators, ventilating shafts, or openings in the walls or roof.

19. Every dairy shall be well paved with flag-stones, concrete, or other suitable material, properly set in cement, and the inner walls thereof shall be covered with hard, smooth, and impervious material to a height of at least 6 feet from the floor of such dairy, and such hard, smooth, and impervious material shall not be covered with cement-wash, lime-wash, or other substance.

20. The floor of every dairy shall fall or slope towards an opening in the walls thereof, leading to a properly trapped gully-hole outside such dairy, and no inlet to a drain shall be within any dairy.

21. Every dairy shall be provided with an adequate supply of water, and, where there is not a constant supply, with a slate, metal, or metallic-lined tank, properly covered, and provided with an overflow or warning pipe, and with piping for conveying the water to the dairy. The tank shall have no communication with any water-closet or drain by means of a waste pipe, and shall be supplied with good and wholesome water, which, if practicable, shall be procured by

the occupier from a public water company, and such tank shall be cleansed as often as may be necessary for keeping the same in a clean condition.

22. The floor of every dairy and the portions of the walls and other parts of the dairy within 6 feet of the floor thereof, as well as all fixtures and tables therein, shall be cleansed with water as frequently as may be necessary for keeping such dairy, fixtures, and tables, in a thoroughly clean and wholesome condition, and the ceilings and the upper parts of the inner surface of the walls shall be thoroughly cleansed and lime-washed as frequently as may be necessary for keeping the same in a clean condition.

23. All utensils and vessels used by a dairyman for the reception, storage, or delivery of milk, shall be thoroughly cleansed with steam or scalding water as frequently as may be necessary for keeping such utensils and vessels perfectly clean and sweet, and only clean water shall be used for the purpose.

24. Every dairyman shall at all times employ such means and adopt such precautions as may be necessary for keeping any dairy in his occupation, and the utensils and vessels used by him for containing milk, in a clean and wholesome condition, so as to preserve the purity of such milk.

25. Every milk store or milk shop, as well as all fixtures and tables therein, used in connection with the keeping or sale of milk, shall at all times be kept in a cleanly condition.

26. All utensils and vessels used for the reception, storage, or delivery of milk, shall be thoroughly cleansed with steam or scalding water as frequently as may be necessary for keeping such utensils and vessels perfectly clean and sweet, and only clean water shall be used for the purpose.

27. Every person following the trade of cow-keeper or dairyman shall, at all times, employ such means and adopt such precautions, as may be necessary for keeping the utensils and vessels used by him for containing milk in a clean

and wholesome condition, so as to preserve the purity of such milk.

28. Every purveyor of milk, or person selling milk by retail, shall immediately on any outbreak of infectious or contagious disease within the building or upon the premises in which he keeps milk, or amongst the persons employed in his business, give notice of such outbreak to the Board at their office in Spring Gardens.

29. Every purveyor of milk, or person selling milk by retail, shall immediately on such outbreak coming to his knowledge, remove all milk for sale and all utensils for containing milk for sale from such building; and shall cease to keep milk for sale or to sell milk in such building until the same has been disinfected and declared by the medical officer of health for the district to be free from infection.

30. Every purveyor of milk, or person selling milk by retail, shall not keep milk for sale in any place where it would be liable to become infected or contaminated by gases or effluvia arising from any sewers, drains, gullies, cesspools, or closets, or by any offensive effluvia from putrid or offensive substances, or by impure air, or by any offensive or deleterious gases or substances.

31. Every purveyor of milk, or person selling milk by retail, shall only keep milk for sale in clean receptacles: and all utensils used in connection with the keeping or sale of such milk shall be at all times kept clean.

32. Every purveyor of milk, or person selling milk by retail, shall at all times employ such means, and adopt such precautions, as may be necessary for preserving the purity of milk, and for protecting it against infection or contamination.

33. The Regulations made by the Board in pursuance of the Dairies, Cow-sheds, and Milk Shops Order of July, 1879, are hereby revoked.

Note.—Any person guilty of an offence against the foregoing order or regulations is liable to a penalty of 5*l.*, and

in the case of a continuing offence, to a further penalty of 40*s.* for each day after written notice of the offence from the Board.

In addition to the foregoing regulations which particularly relate to cow-sheds, dairies, &c., there are also certain others which must be complied with whenever it is found necessary to construct living rooms directly over stables, and also when it is required to provide dung-pits or cesspools in connection with stables or other buildings within the same area. The conditions which govern the general construction of rooms over stables, together with the staircase leading thereto, are laid down in the London Building Act, of 1894, 57 and 58 Vic., c. 213, whilst the regulations respecting dung-pits or cesspools form a portion of the by-laws made by the London County Council under the Public Health (London) Act of 1891.

The following is an extract from Section 70 of the London Building Act of 1894, viz. :—

"(1) (*e*) Every habitable room constructed over a stable shall be separated from the stable by a floor which shall have, in every part not occupied by a joist or girder, a layer of concrete pugging of good quality, or of other solid construction, 3 inches in thickness, finished smooth upon the upper surface and properly supported; and the under side of such floor shall be ceiled with lath and plaster of good quality or of other solid construction.

"Any staircase or gallery or structure by which such rooms shall be approached shall be separated from any stable to which it may adjoin by a brick wall not less than 9 inches in thickness.

"(2) If any person knowingly suffer any room, constructed after the commencement of this Act, that is not constructed in conformity with this section, to be inhabited, he shall, in addition to any other liabilities to which he may be subject, be liable to a penalty for every day during which such room is inhabited."

Note.—For any contravention of this section a person is liable to a penalty of 40*s.*, and to a daily penalty of 40*s.*

By virtue of the powers conferred on the London County Council under Section 39 (1) of the Public Health (London) Act, 1891, that authority has formulated a group of by-laws dealing with the construction of "water-closets, earth-closets, privies, ashpits, cesspools, and receptacles for dung, and the proper accessories thereof in connection with buildings." These regulations apply throughout the area comprised within their jurisdiction.

The by-laws which specifically refer to the construction and cleansing of cesspools, dung-pits, &c., are as follows, viz.:—

"20. Every person who shall construct a cesspool in connection with a building, shall construct such cesspool at a distance of 100 feet at the least from a dwelling-house or public building, or any building in which any person may be, or may be intended to be, employed in any manufacture, trade, or business.

"21. A person who shall construct a cesspool in connection with a building, shall not construct such cesspool within the distance of 100 feet from any well, spring, or stream of water.

"22. Every person who shall construct a cesspool in connection with a building, shall construct such cesspool in such a manner and in such a position as to afford ready means of access to such cesspool, for the purpose of cleansing such cesspool, and of removing the contents thereof, and in such a manner and in such a position as to admit of the contents of such cesspool being removed therefrom, and from the premises to which such cesspool may belong, without being carried through any dwelling-house, or public building, or any building in which any person may be, or may be intended to be, employed in any manufacture, trade, or business.

"He shall not in any case construct such cesspool so that it shall have, by drain or otherwise, any means of communication with any sewer or any overflow outlet.

"23. Every person who shall construct a cesspool in connection with a building, shall construct such cesspool of good brickwork bedded and grouted in cement, properly rendered inside with cement, and with a backing of at least 9 inches of well-puddled clay around and beneath such brickwork, and so that such cesspool shall be perfectly water-tight.

"He shall also cause such cesspool to be arched or otherwise properly covered over, and to be provided with adequate means of ventilation.

"24. A person shall not use as a receptacle for dung any receptacle so constructed or placed that one of its sides shall be formed by the wall of any room used for human habitation, or under a dwelling-house, factory, workshop, or workplace, and he shall not use any receptacle in such a situation that it would be likely to cause a nuisance or become injurious or dangerous to health.

"25. Every owner of any existing receptacle for dung shall, before the expiration of six months from the date of the confirmation of these by-laws, and every person who shall construct a receptacle for dung, shall cause such receptacle to be so constructed that its capacity shall not be greater than 2 cubic yards, and so that the bottom or floor thereof shall not, in any case, be lower than the surface of the ground adjoining such receptacle.

"He shall so construct such receptacle that a sufficient part of one of its sides shall be readily removable for the purpose of facilitating cleansing.

"He shall also cause such receptacle to be constructed in such a manner and of such materials, and to be maintained at all times in such a condition as to prevent any escape of the contents thereof, or any soakage therefrom into the ground or into the wall of any building.

"He shall cause such receptacle to be so constructed that no rain or water can enter therein, and so that it shall be freely ventilated into the external air.

"Provided that a person who shall construct a receptacle

for dung, the whole of the contents of which are removed not less frequently than every forty-eight hours, shall not be required to construct such receptacle so that its capacity shall not be greater than two cubic yards.

"And provided that a person who shall construct a receptacle for dung, which shall contain only dung of horses, asses, or mules with stable litter, and the whole of the contents of which are removed not less frequently than every forty-eight hours, may, instead of all other requirements of this by-law, construct a metal cage, and shall beneath such metal cage adequately pave the ground at a level not lower than the surrounding ground, and in such a manner and to such an extent as will prevent any soakage into the ground; and if such cage be placed near to or against any building he shall adequately cement the wall of such building in such a manner and to such an extent as will prevent any soakage from the dung within or upon such receptacle into the wall of such building.

"26. The occupier of any premises shall once at least in every week cause every earth-closet, privy, and receptacle for dung belonging to such premises to be emptied and thoroughly cleansed.

"The occupier of any premises shall once at least in every three months cause every cesspool belonging to such premises to be emptied and thoroughly cleansed.

"27. The owner of any premises shall maintain in proper condition of repair every water-closet, earth-closet, privy, ashpit, cesspool, and receptacle for dung, and the proper accessories thereof belonging to such premises.

"28. Every person who shall offend against any of the foregoing by-laws shall be liable for every such offence to a penalty of 5*l*., and, in the case of a continuing offence, to a further penalty of 40*s*. for each day after written notice of the offence from the sanitary authority. Provided nevertheless that the Court before whom any complaint may be made or any proceedings may be taken in respect of any such

offence may, if the Court think fit, adjudge the payment as a penalty of any sum less than the full amount of the penalty imposed by this by-law."

The by-laws which have been framed by the different local authorities for regulating the sanitary condition of stable and other buildings situated in their respective districts vary somewhat in detail, according to local circumstances, but in the more important particulars they are essentially the same as those just quoted. From the most cursory perusal of these regulations it at once becomes apparent how necessary it is that the hygienic construction of stable buildings—especially cow-houses and their appurtenances—should receive the most careful attention. Neglect of such precautions must necessarily exert a far-reaching effect upon the public health, and for this reason, if for no other, it is important that an adequate standard of sanitary efficiency should in all cases be maintained.

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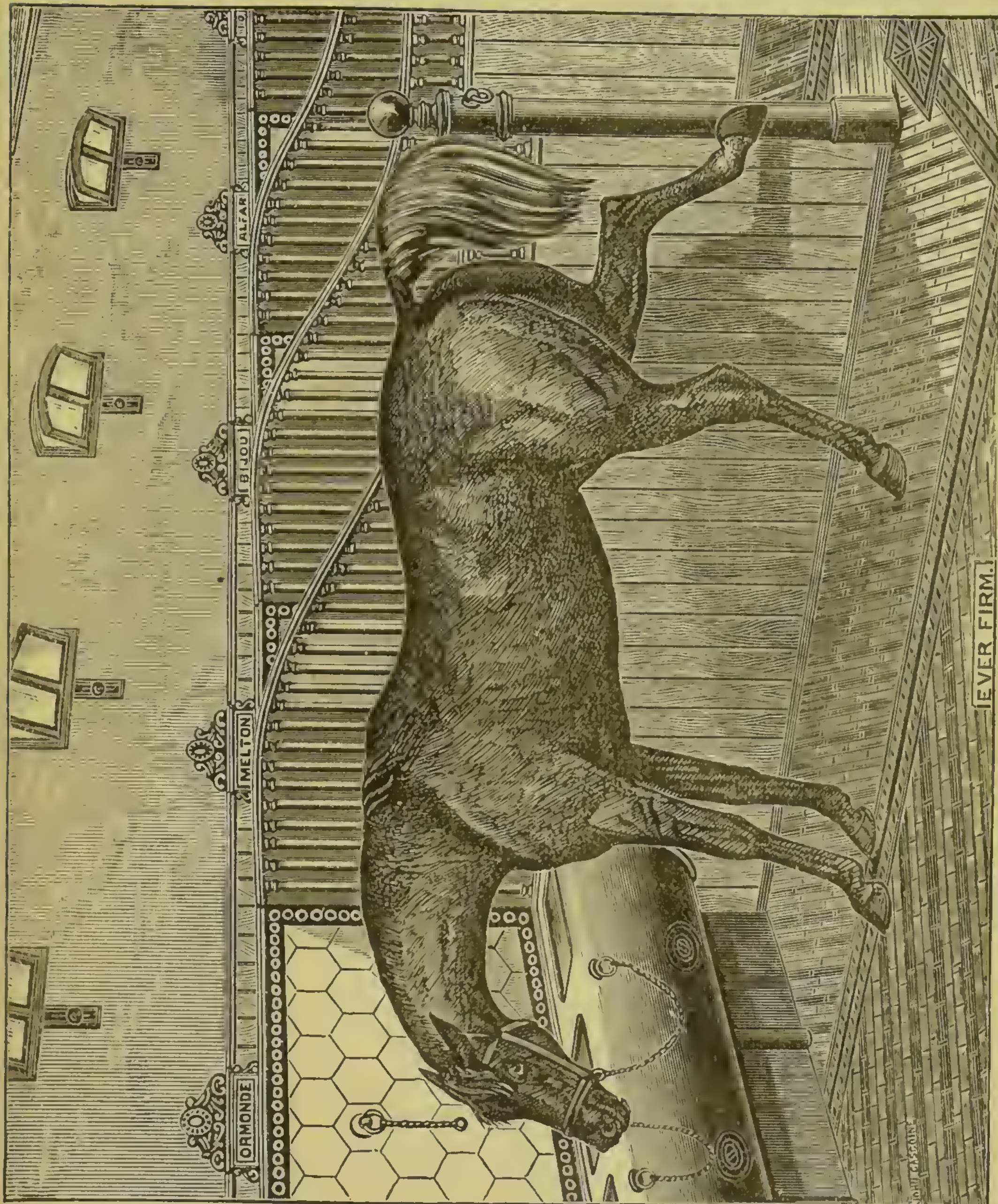
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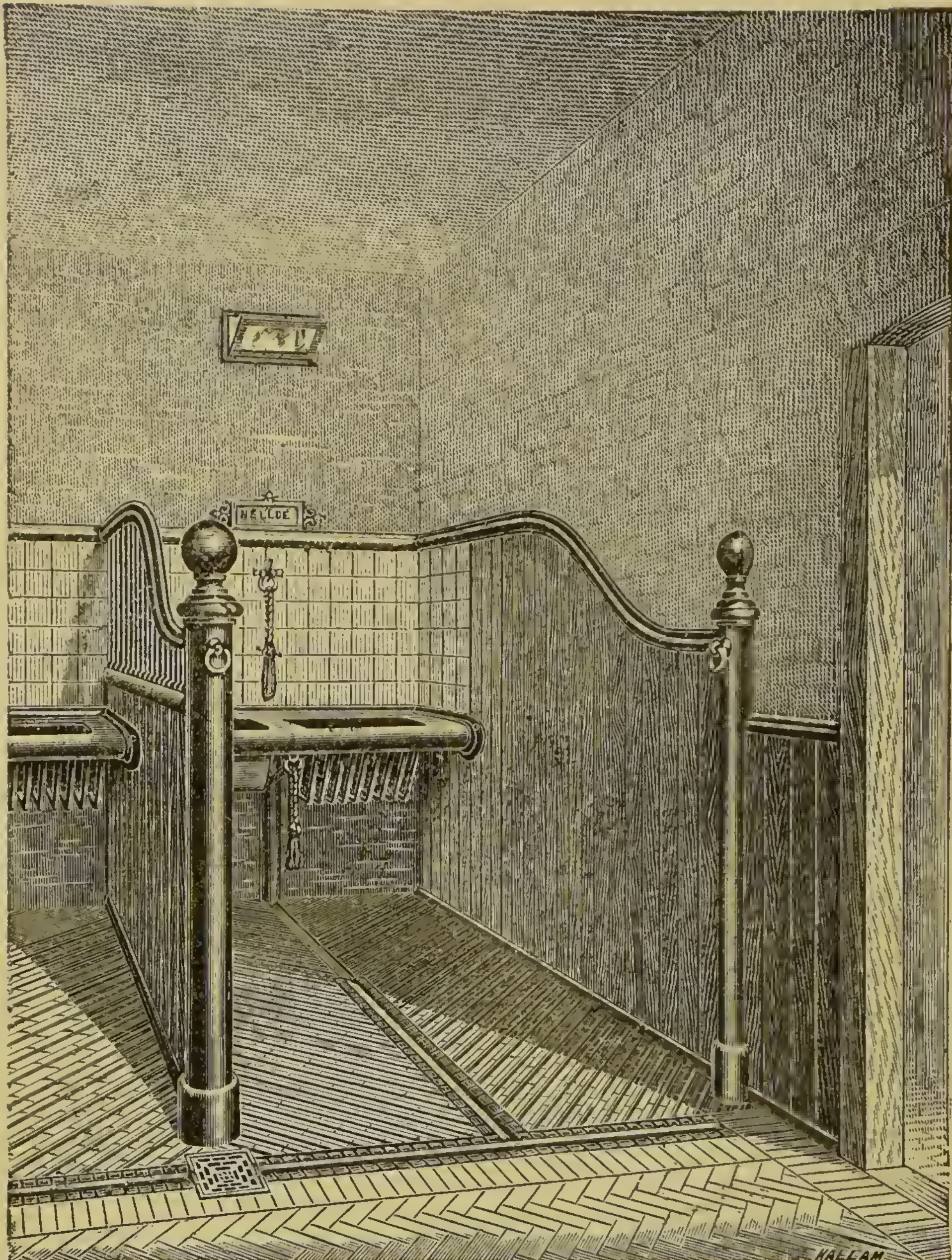

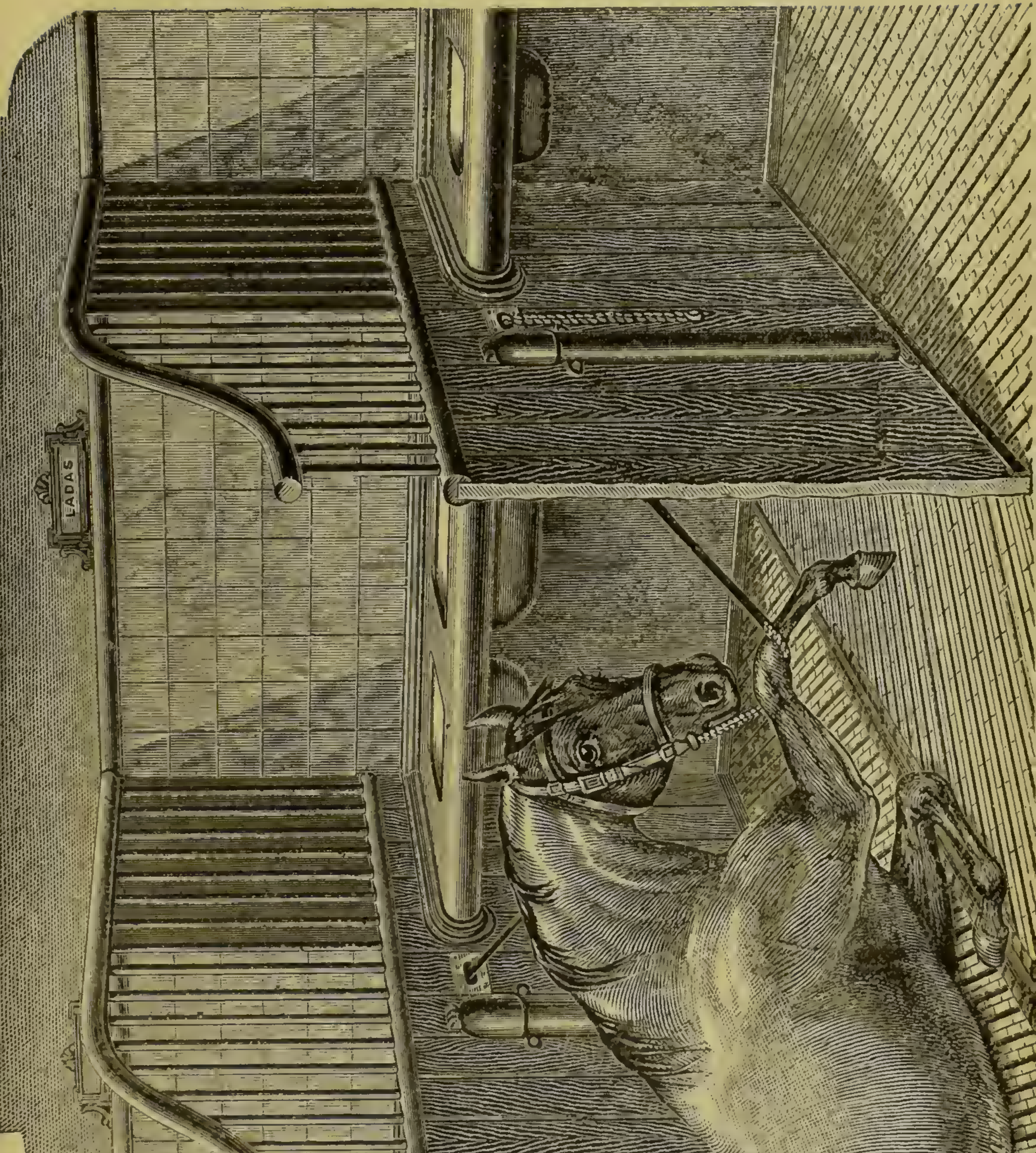
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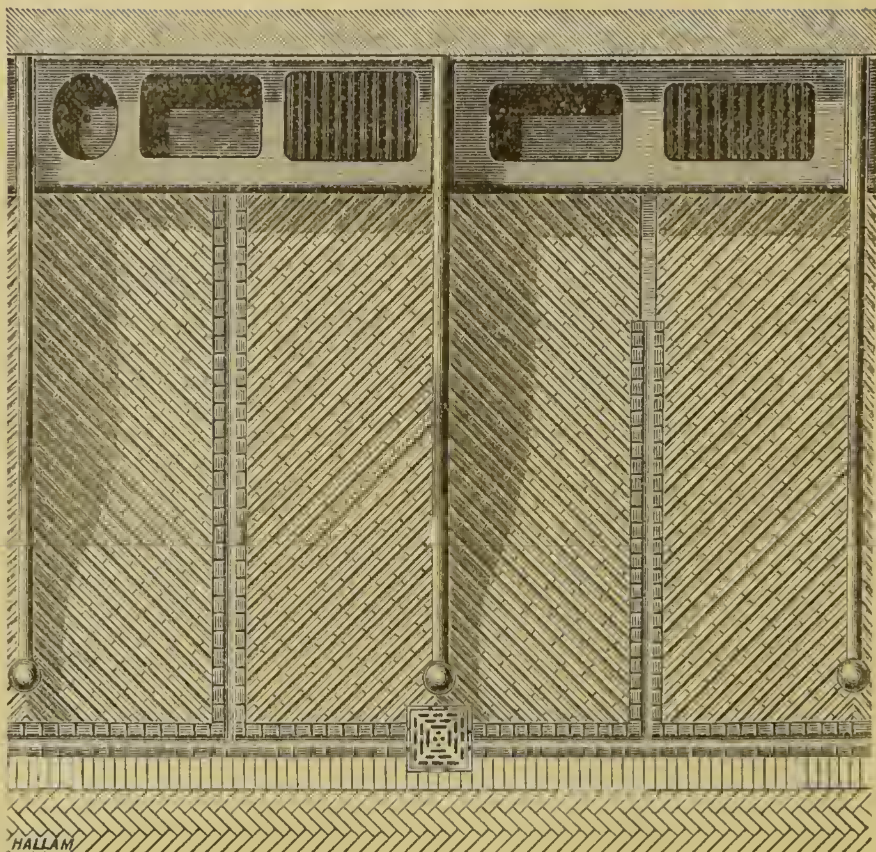
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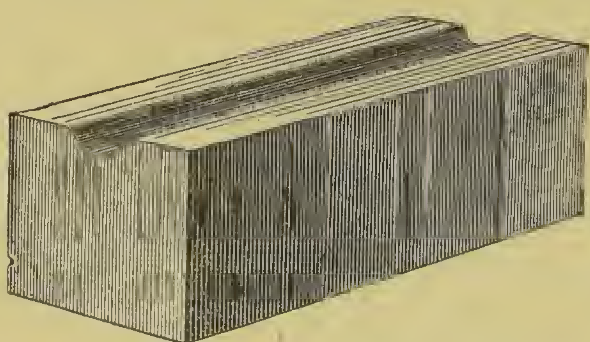

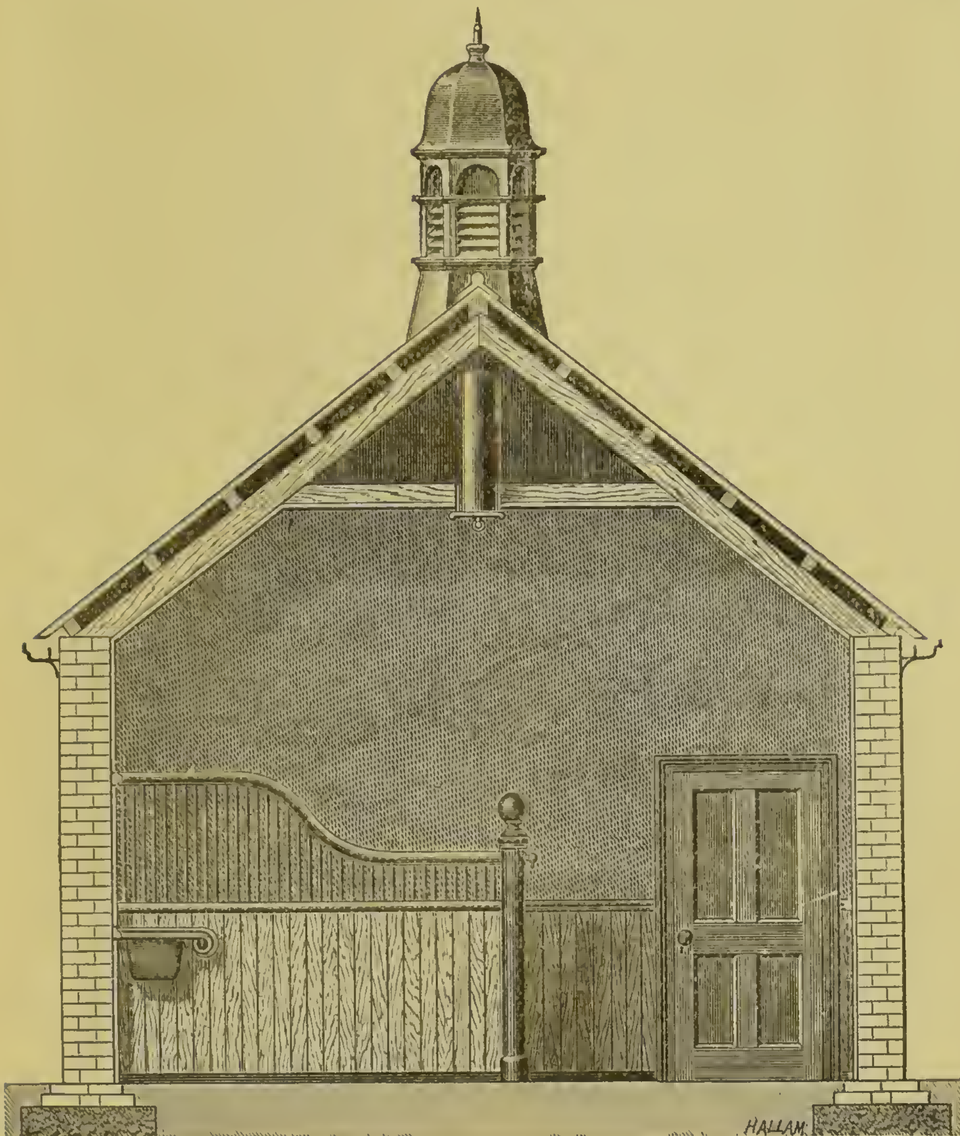
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BY

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